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Interim Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB)

4-7 April 2017

Nelson, New Zealand

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Executive summary

The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) met in Nelson, New Zealand on 4–7 April 2017. The meeting was chaired by Haraldur Arnar Einarsson (MFRI, Iceland) and Petri Suuronen (FAO, Italy), and the rapporteur was Steve Eayrs (GMRI, USA). The meeting was kindly hosted by the New Zealand National Institute of Water and Atmospheric Research (NIWA). A joint session (JFTAB) was also held on 3 April 2017 with the Working Group on Fisheries Acoustics and Fishing Technology (WGFAST).

A total of 73 participants from 15 counties were registered to the WGFTFB meeting. The location of the meeting provided a rare opportunity for the WGFTFB to engage with researchers and others from New Zealand and Australia, and learn of developments and challenges in southern hemisphere fisheries. However, some WGFTFB members were unable to attend the meeting due to its distant location.

Overall, the dominant research theme of this meeting was fishing gear selectivity, primarily related to trawl gear and to a lesser extent, traps and hook and line gear. The geographical focus of this research was Europe, USA, New Zealand, and Australia, with research also presented from other countries including Canada, China Kenya, and Korea. Other research themes included challenges of facilitating voluntary change in fisheries, LIFE fishing, and energy conservation.

The meeting was divided into eight sessions, including a session dedicated to Topic Group meetings and another to WGFTFB business. Prior to the first session Petri Suuronen provided a description of ongoing and future FAO projects relevant to the WGFTFB, including efforts to reassess global fisheries discards, a program for development of International Guidelines on marking of fishing gear for combating abandoned, lost or otherwise discarded fishing gear (ALDFG), and a new project focusing on reduction of discards in tropical shrimp trawling in Latin American and Caribbean fisheries. Petri also summarized ongoing projects related to the development of low impact and fuel efficient (LIFE) fishing gears and practices.

The first session was titled *Facilitating change in commercial fisheries: Successes, challenges, and human behaviour*. Six presenters described experiences facilitating change in fisheries from around the world. A common theme was that facilitating change in fisheries is extremely challenging, and often less successful than anticipated. The next session, *New Zealand bycatch issues*, provided the WGFTFB an opportunity to learn of local issues, developments, and successes in bycatch reduction. In the final session of the day, *Gear developme*nt, two presenters from New Zealand described the testing and development of a modular harvesting system to capture fish sustainably and allow the escape and release of unwanted catch unharmed. Two other presentors focused on LIFE fishing. The first session of the second day, *Technology for efficient and selective harvesting of crustaceans*, focused primarily on reducing bycatch in *Nephrops* fisheries. The next session, *Means and methods to mitigate bycatch, discards, and seabed impact*, included multiple presentations describing efforts to improve gear selectivity from around the world, including USA, Australia, Korea, and Antarctica. The third day was dedicated to the Topic Groups and energy efficient fishing. The final day commenced with a session titled, *Fisheries and gear technology in Kenya and tuna fisheries*, with one presenter describing the relationship between cpue and vessel motorization in Lake Victoria, Kenya, and another on developments in Chinese tuna fisheries. The day concluded with WGFTFB business, including Topic Group summaries, including requests from other ICES Working Group and location of the next meeting.

1 Administrative details

Working Group name

ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB)

Year of Appointment within the current three-year cycle

2016

Reporting year concluding the current three-year cycle

1

Chairs

Haraldur Arnar Einarsson (ICES Chair), Iceland

Petri Suuronen (FAO Chair), Italy

Rapporteur: Steve Eayrs, USA

Meeting venue

Nelson, New Zealand

Meeting dates

4–7 April 2017

2 Introduction

Directive

The directive of the WGFTFB is to initiate and review investigations of scientists and technologists concerned with all aspects of the design, planning, and testing of fishing gears used in abundance estimation, selective fishing gears for bycatch, and discard reduction, as well as environmentally benign fishing gears and methods with reduced impact on the seabed and other non-target ecosystem components.

The Working Group's activities shall focus on all measurements and observations pertaining to both scientific and commercial fishing gears, design and statistical methods and operations including benthic impacts, vessels, and behaviour of fish in relation to fishing operations. The Working Group shall provide advice on application of these techniques to aquatic ecologists, assessment biologists, fishery managers, and industry.

3 Term of Reference

The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) chaired by Haraldur A. Einarsson, Iceland and Petri Suuronen, FAO, met on 4–7 April 2017 in Nelson, New Zealand to work on the following specific Terms of References that were developed from WGFTFB's multi-annual ToRs (Annex 5).

The Term of Reference for this year Topic groups was following:

Contact Probability of Selective Devices (Contact)

As the conveners of this topic group could not attend to this year the meeting was postponed until next year. The next meeting will be the final meeting for this topic group.

Change Management in Fisheries (Change)

A WGFTFB topic group convened by Steve Eayrs (USA) and Michael Pol (USA) held its third and final meeting to evaluate the application of change management concepts and models in a fisheries context and recommend new approaches to facilitate change in the fishing industry.

Terms of reference:

Evaluate the applicability of change management concepts and models in a fisheries context

Review and evaluate fisheries case studies and initiatives to bring about change, including Knowledge networks, Environmental Management Systems, Fisheries Improvement Projects, and others

Explore models of human behaviour that may contribute to resistance to change

Identify and categorize circumstances and approaches that led to both the successful and unsuccessful introduction of change initiatives in fisheries.

The topic group report provided herein should be considered the final report of the topic group, and contains results of the online survey and summaries of meetings in 2015 and 2016.

Evaluation of trawl groundgear for efficiency, bycatch, and impact on the seabed (Groundgear)

A WGFTFB topic group convened by Roger B. Larsen (Norway), Antonello Sala (Italy) and Pingguo He (USA) met to discuss knowledge of groundgear designs and other components that contact the seabed during bottom trawling.

Terms of reference:

1) Describing and summarizing current and past work in relation to seabed contact/impact of various types of bottom-trawl groundgear.
2) Discussing and describing possible methods to reduce unnecessary bottom contact and fuel use due to the groundgear.
3) Discussing and summarizing the effect of trawl groundgear on the efficiency and selectivity for target and bycatch species.
4) Making recommendations on future experimental and theoretical work to understand and improve the function of groundgear of bottom trawls.
5) Making recommendations on the "best practice" regarding the design and operation of bottom trawls with less effect on ecosystem and emission.

Assessment on energy use and fuel consumption in fisheries (Energy)

A WGFTFB topic group convened by Emilio Notti (Italy) and Steve Eayrs (USA) met to discuss the state-of-the-art in energy audit data collection protocols and collect summary information on energy use in fisheries. A deeper analysis of energy consumption through standardization of the energy profile of fishing boats is a keynote action for a better understanding of different fishing activities, including comparison of audits between fleets. Collection of information of the most relevant technical specifications will allow for a characterization and a comparison of different fisheries among different areas, and prioritization of future research efforts. The efficiency of several fisheries will be compared using common performance metrics such as catch/fuel consumption ratio.

Terms of reference:

6) Identification of energy audit testing protocols and performance metrics e.g. country, fisheries, fleet sector, etc. including monitoring of GHG emissions;

7) Evaluation of the potential to harmonize audit protocols for information collection of energy use in different fisheries;

8) Design of a general dataset for data and information collected, open data;

9) Definition of performance metrics e.g. l/h; l/kg of catch, litre of fuel/nautical mile etc. and identify and discuss equipment and tools to evaluate performance.

This was a one-year topic group and the report herein should be considered the final report.

4 Participants and Meeting Agenda

A full list of participants I given in Annex 1. The agenda is included in Annex 2.

5 Explanatory Note on Meeting and Report Structure

The meeting was comprised primarily of three sessions; an open session of presentations to plenary, a topic group session, and a session discussing WGFTFB business. The open session was further divided into subsessions, with presentations related to the following:

- Facilitating change in commercial fisheries: Successes, challenges, and human behaviour;
- New Zealand Bycatch issues;
- Gear development;
- Technology for efficient and selective harvesting of Crustaceans;
- Means and methods to mitigate bycatch, discards, and seabed impact;
- Topic group meetings;
- Fisheries and gear technology in Kenya and Tuna fishery.

The session, WGFTFB business included reports by topic group conveners on the outcomes of the respective topic group, as well as other important procedural matters.

The conveners of ToRs prepared a working document, reviewing their progress on their ToRs and recommendations and conclusions based on the topic group's work. The summaries and recommendations for the working documents for each ToR were reviewed by WGFTFB and were accepted at the meeting, rejected or modified accordingly to reflect the views of the WGFTFB. However, the contents of these working documents do not necessarily reflect the opinion of the WGFTFB. Some topic groups included small numbers of individual presentations based on specific research programmes related to that topic. The abstracts are included in this report, together with the authors' names and affiliations. Although discussion relating to the individual presentations was encouraged and some of the comments are included in the text of this report, the contents of the individual abstracts were not discussed fully by the group, and as such they do not necessarily reflect the views of the WGFTFB. National reports are displayed in this report like has been the practice in the WGFTFB annual report before.

6 Opening of the meeting

The main opening of the meeting for WGFTFB and WGFAST was officially held on 3 April at the beginning of the JFATB meeting. Therefore, there was none formally presentations at the opening of WGFTFB meeting. At the beginning of the WGFTFB meeting the chair welcomed all participants, provided an overview of the meeting, and discussed the agenda.

Just under 60 individuals attended the meeting, although it was clear the meeting location had negatively affected the number of individuals in attendance, particularly from ICES Member Countries (Figure 6.1). With more than half the participants from New Zealand, Australia, and Asia, the meeting provided an opportunity for WGFTFB members to learn of issues and problems in fisheries in distant regions of the world. However, an opportunity to discuss problems and issues in ICES Member Countries was significantly constrained.

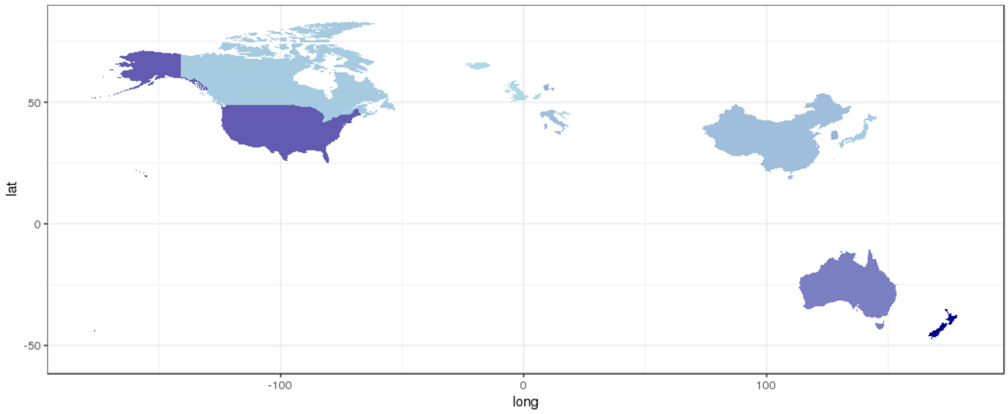

Figure 6.1. The figure shows the countries of origin of the WGFTFB participants. The strength of the colour represent how many was from each country. (New Zealand – 18, USA – 11, Australia – 8, Denmark – 4, South Korea – 4, China -3, Italy – 3, Canada – 2, Japan – 2, Croatia -1, Netherlands – 1, UK – 1, Iceland – 1.)

7 Open Session Presentations

7.1 FAO briefing on relevant activities

The FAO Fishing Operation and Technology Branch (FIAO) has currently activities in the following projects (or is planning activities in the near future):

7.1.1 Re-assessment of global fisheries discards

FAO has commissioned two global assessments of fisheries discards: (i) Alverson *et al.* (1994) that estimated global discards at around 27 million tonnes, and (ii) Kelleher (2005) that gave an average estimate of 7.3 million tonnes. Although the results of these studies are not directly comparable, they indicate a decline in discarding. In fact, significant changes have occurred in many fisheries mainly because of (i) wider utilization of fish that were previously discarded; (ii) adoption of more selective fishing technologies; (iii) implementation of other management measures; and (iv) better awareness of discard problem.

Nonetheless, there are major global concerns that the combined effect of failing to effectively manage bycatch is threatening the long-term sustainability of fisheries and the maintenance of biodiversity, and is also contributing to food insecurity, thus affecting the livelihoods on those dependent on fish resources. Discards represent a significant loss of food (food wastage).

To understand how fisheries are currently performing in reducing discards and seafood wastage, updated information is needed of global quantity and composition of discards. This information will help to (i) design national and multilateral initiatives to promote responsible fishing operations, (ii) address the concerns of failing to effectively manage bycatch, and (iii) improve the assessment of fish stocks.

The ongoing FAO reassessment of global discards is based on existing fisheries data, information and studies. The project is using regional specialists focusing on specific regions and fisheries. There is close cooperation with countries, the regional fisheries bodies, non-governmental organizations, and fishing sector.

It is worth noting that more programs and advanced methods are currently in place to monitor and report catches and discards, and thereby there is more reliable information available than during the earlier assessments. These methods include observer programs, electronic monitoring and electronic logbooks, onboard video camera monitoring schemes, smartphone recording, fisheries surveys, fisher interviews and collaborative sampling schemes, and sophisticated systems and techniques for collecting data. Many of these methods were not available a decade ago. Nonetheless, in most parts of the world data on discards is still very limited (or none).

The assessment is planned be completed by the end of 2017 and published in 2018. Key outputs include a report providing a quantification of global discards and analysis of priority issues in reduction of waste in fisheries, and recommendations on the management of discards and bycatch. The project also aims to prepare a publicly available global fishery-by-fishery discard information base that can be automatically updated on a regular basis but it is not yet sure whether there will be enough resources for that.

7.1.2 Development of International Guidelines on the Marking of Fishing Gear for combating ALDFG and Ghost Fishing

There are increased global concern about environmental impacts of abandoned, lost or otherwise discarded fishing gear (ALDFG). There are growing concern also about the link between ALDFG and IUU.

FAO organized in April 2016 an Expert Consultation on the Marking of Fishing Gear. The Consultation was attended by 18 invited experts. The main outcome was Draft Guidelines on Marking of Fishing Gear.

The Experts noted that the marking system has to be simple and affordable, and permit easy identification of ownership of gear, fishery of origin, and position of gear. Furthermore, marks should easily be attached or embedded to fishing gear and should not interfere with the performance of the gear. Marks should be easily recognized and identified. The marking system should be flexible and dependent on risk assessment. The implementation should be at acceptable cost. The system should, when feasible, adopt emerging new technologies.

Potential long-term benefits of appropriate marking of fishing gear include reduced quantity of ALDFG, reduced entanglement risk for marine species, and reduced habitat damage caused by ALDFG. Furthermore, reduced loss of potential catch, easier recovery of lost gear and reduced time spent trying to recover lost gear would be of direct benefit for the fishing sector. Appropriate marking may also contribute in reducing illegal operations and thereby provide more fish for authorized fishers. Finally, safety at sea would improve.

The Expert Consultation noted that gear marking is only a part of the solution. Fisheries are all different and require different solutions. Experts also noted that Fish Aggregating Devises (FADs) is of increasing significance and requires special attention. Experts also note that illegal fishers are unlikely to comply with the guidelines so traceability of gear through manufactures is important. Broad stakeholder participation and capacity building is essential.

In July 2016, the FAO Committee on Fisheries (COFI 32) welcomed the recommendations from the Expert Consultation, noting that gear marking can be a critical tool for reducing ALDFG and IUU, and proposed the Technical Consultation to further develop the guidelines on marking of fishing gear. COFI also encouraged FAO to conduct pilot projects on fishing gear marking in developing countries to facilitate the implementation of these guidelines.

Two pilot projects on gear marking will be conducted by FAO in 2017–2018 to demonstrate feasibility and benefits for developing countries, test new or emerging gear marking technologies, and show a measurable impact in the prevention of ALDFG. One of these pilot projects is dealing with the gillnet fisheries in Indonesia and the other with Fish Aggregating Devices. Technical Consultation on the Marking of Fishing Gear will be held in February 2018 in Rome.

7.1.3 Bycatch management and reduction of discards in tropical shrimp trawling (REBYC-II)

In shrimp and bottom-trawl fisheries, the overall discards were in early 2000s about 3.6 million tonnes which was almost half of the total global fisheries discards (Kelleher, 2005). From the food production point of view these discards represent inefficiency and waste. If utilized, those fish can decrease vulnerability of fishing communities via more food or more revenue from sales.

In tropical bottom trawling the bycatch and discards consists of large number of species which are often small in size and difficult to process. Bycatch often include large amount of juvenile fish. Sustainable part of the discards could be utilized. Discards are a potential source of essential nutrients. Processing technologies have improved dramatically and previously discarded species are now being processed and utilized in some countries. More can be done.

Two of the key objectives of the REBYC-II LAC (Sustainable management of bycatch in Latin America and Caribbean trawl fisheries) project is a better management of trawl fisheries and more efficient utilization of currently wasted resources (discards) in Latin America. The project runs from 2015 to 2020.

7.1.4 Reduction of marine mammal bycatch

Entanglement of marine mammals in fishing gear is a major global threat to these animals. FAO is planning an Expert Workshop in Rome in March 2018. The workshop will be funded by NOAA. The overall goal is to find practical solutions and best practices that would help to reduce marine mammal bycatches in fisheries. One potential area of collaboration with FTFB could be the development of alternative capture technologies for fisheries where marine mammal bycatch is critical and difficult to avoid.

7.1.5 Activities on LIFE-fishing

There is a large number of projects going on around the world where the goal is to develop low impact and fuel efficient (LIFE) fishing gears and practices. FAO has contributed in some of these projects. FAO is planning in the near future to focus on developing alternative captures methods for shrimp (*especially for countries where shrimp trawling has been banned*). The major issue is how to improve the capture efficiency of the alternative gears. Extensive research and testing activities, and new technological innovations, are needed. FAO may also continue work in other areas, including the fishing vessel Energy Audits.

7.1.6 Trawling Best Practices

The project "*Finding common ground on the scientific knowledge regarding best practices in trawling*" is an international collaboration to understand how trawling and other forms of towed bottom fishing gears interact with marine seabed habitats and their biota. The project brings together global datasets on the spatial distribution of trawl fishing activities and the impact of trawling on marine ecosystems and productivity and uses this information to understand the extent and consequence of trawling at a global scale and on a regional basis. The goal is to identify a range of suitable "best practices" for trawling and determine the consequences of adoption of these practices on biota, sustainable food production and ecosystem services. Key questions: how does trawling affect the long-term sustainable yield of aquatic resources from an ecosystem, and how does trawling affect other ecosystem services.

Much of the scientific information available on trawling impacts, however, comes from fisheries in temperate waters. There is an urgent need for a global synthesis that includes also tropical trawl fisheries. Tropical areas are important through the amount of trawl fishing and significantly contribute to the provision of food and livelihoods. FAO is a project partner and has helped to expand the analysis to include also the developing countries.

7.1.7 Fishing Vessel Energy Audit

FAO conducted in collaboration with SEAFDEC in 2013–2015 fishing vessel energy audit in Thailand. The key conclusions were that audits can help to identify a variety of fuel-saving options and payback periods and allow critical questions of the fishing operation to be asked. It was noted that recollection of overall costs of fishing operations by fishers are not always accurate and their enthusiasm can be weak. Audit protocols still poorly established. The low-cost fuel saving options in Thailand include hull cleaning, fuel flowmeters, improved trip planning, raised awareness and handling changes

7.2 Facilitating change in commercial fisheries: Successes, challenges, and human behaviour

Introducing the session

Steve Eayrs (steve@gmri.org)

The purpose of this session was to i) explore the concept of change in the fishing industry, including challenges and opportunities, ii) provide an opportunity to hear of southern hemisphere experiences in facilitating change with fishers, iii) increase awareness of the role of social science, including understanding human decision-making in facilitating change, and iv) heighten awareness of the change management in fisheries topic group.

Change Process Structure. How to succeed with change management in challenging circumstances?

Richard Wells (richard@resourcewise.co.nz)

New Zealand fisheries, both deep water and more recently coastal, have over the last 20 years needed to adopt an increasing number of regulatory or quota-owner required procedures and processes to reduce actual or risk of environmental impacts by fishing (notably incidental captures of seabirds and marine mammals). For the fleet over the last 10 years this has meant a need for actions, equipment (costs) and reporting requirements well beyond those already undertaken to earn their livelihood. There was a need for urgency. This presentation will focus on tools and systems brought to bear to ensure implementation and uptake of these requirements. The deep-water fleet consists of mostly large trawlers crewed by either New Zealanders or overseas nationals e.g. Korea, Russia/Ukraine, and Japan. The coastal fleet is numerically much bigger, more geographically spread and with weaker communications. Quota owners appreciated the need for effective implementation and hence resourcing of programs is shared between Government and industry. The processes have been based on two main philosophies keep in mind the client (i.e. the fisher) and be systematic. Tools and actions have been drawn directly from maritime safety as well as USA based corporate business improvement and change management processes. It has been delivered the face of what has usually (but not always) been apathy or even antipathy towards the objectives of the program. Thus creating motivation within the fleet, delivering messages and procedures in a consistent way and allowing audit and review processes have been paramount. This has by necessity lead to a multidimensional approach which has had to include not just the fishers but Government management and observer agencies and quota owners. The strengths, weaknesses and future opportunities of the approach as well as the extent of culture change and improvement in various sectors of the fleet will be discussed.

NPF Industry Pty Ltd – driving industry innovation to address bycatch in Prawn

Adrianne Laird (adrianne@npfindustry.com.au)

Australia's Northern NPF Industry Pty Ltd (NPFI), the industry association representing Australia's MSC-certified Northern Prawn Fishery operators, is recognized as being a global leader in fisheries management and sustainability. Being a tropical prawn trawl fishery, bycatch interactions are one of the key challenges facing the NPF. In a bold move to build on previous bycatch reduction strategies, NPF Industry embarked on a mission in 2015 to reduce small bycatch by 30% by 2018. The NPF Bycatch Strategy 2015–2018 was developed and implemented by NPF Industry, in consultation with other NPF stakeholders including managers and scientists. In acknowledging that the best sustainability solutions are often found by those on the water, a key element of the Strategy was to incentivise development and innovation in BRD designs or gear modifications by NPF skippers and crew. Through this process a number of new bycatch reduction devices (BRDs) were designed by industry and tested during commercial fishing operations in preliminary industry trials and then scientific trials in 2016. The Kon's Covered Fisheyes (KCF) device was developed and tested through this process and was proven to be the most successful BRD ever developed for the NPF, achieving a 36.7% reduction in small bycatch, compared to a currently approved device, and no prawn loss. The KFC has now been formally approved for use in the fishery. The successful implementation of the NPF Bycatch Strategy demonstrates how industry innovation and collaboration with other fishery stakeholders can lead to positive solutions in bycatch management.

Introducing the 'Trawl Knowhow' project - disseminating gear technology information to fishers

Jereon van der Kooij (jeroen.vanderkooij@cefas.co.uk), Tom Catchpole, Stephen Mangi, Stuart Hetherington, Helen Egar, Suzanna Neville, Katrina Barrow, Harriet Yates-Smith

A new European fisheries policy introduces a phased discard ban, under which the full catch of regulated species must be landed and counted against quota. This landing obligation started on 1 January 2015, and introduces other fisheries through to 1 January 2019. The expectation is that this policy will encourage fishers to avoid unwanted catches by altering their fishing practices because there will be no economic gain in retaining small low-value fish. Improved selectivity of fishing gears remains a primary tool to avoid discards. A wide range of fishing gear based measures have been developed and trialled in Europe, many delivering positive results and showing improvements in selectivity. While there are numerous ways in which the selectivity of a trawl can be changed, the technical details of tested designs and the results of their performance is often difficult for fishing vessel operators to access and interpret. Cefas have begun creating a database of gear technology developments, which provides a central repository to store information on the fishing gears tested and the results from those trials. The next step is to get this information to fishers. Here we introduce a new project Trawl Knowhow. The aim of Trawl Knowhow is to collate information on gear trials, mould it into a useful format, and get it to the people that can use it. A dedicated communications partner will provide a key role in achieving this aim.

Industry-led fishing gear selectivity improvements: Ideas and lessons learned

Jordan Feekings, Ludvig Krag, Tiago Malta, Henrik Lund (jpfe@aqua.dtu.dk)

In 2016, a programme was initiated in Denmark to help facilitate the implementation of the new European Union (EU) Common Fisheries Policy (CFP) and the introduction of the Landing Obligation. The programme's objective has been to allow the development of gear selectivity solutions developed by the fishing industry and have these tested in collaboration with scientists. This follows on from the notion that the problems encountered during the implementation of the CPF will not be the same for all fishers and hence the solutions required to tackle these problems will also differ. Additionally, solutions will need to be found relatively quickly before financial difficulties become too severe. Therefore, the programme aims to facilitate and fast track the testing of new designs proposed by stakeholders and their implementation in legislation. After the programme's first year there have been several gears trialled as well as numerous lessons learned when it comes to involving stakeholders. Here we present the ideas which have been tested under the programme so far, their preliminary results, as well as discuss the lessons learned along the way. Furthermore, we show that it is possible to establish a programme with active voluntary participation from the industry without an extensive incentive package.

Change readiness. How can we know if fishers are ready to change?

Steve Eayrs (steve@gmri.org)

Facilitating change in the fishing industry is a significant challenge that requires an understanding of the concerns and fears of fishers and their impediments to change, both perceived and real. The organizational change management literature can deepen our understanding of the challenges of change in the fishing industry, and stimulate new ways of engaging with fishers. This includes understanding the readiness of fishers to change, an important early step that can increase the likelihood of a successful change initiative. This presentation will focus on the readiness of fishers to change, and it will complement presentations from recent WGFTFB meetings that focused on change type, process, and inertia. An evaluation of change readiness can be achieved using a survey to question intended change recipients, with questions designed to explore the affective and cognitive readiness of individuals to change. The responses of these individuals can then be used to pinpoint their specific concerns and identify where remedial efforts should be focused. This presentation will describe an ongoing evaluation of the readiness of lobster fishers in the Gulf of Maine to change in response to increasing ocean temperatures and associated changes in fish distribution and abundance. The design of the survey is presented and interpretation of results to date and their implication for remedial effort will be described. The applicability of this survey to evaluate the readiness of fishers to other changes, such as adoption of new fishing gear or fishing practice, will also be described.

Fisher Selectivity: The Science of How to Engage the Best Fishers for Inventing Bycatch Solutions

Lekelia D. Jenkins (kiki.jenkins@asu.edu)

When addressing bycatch, the proverbial wisdom is that projects must involve fishers from the beginning of the process. How is this best done? Using comparative case study analysis, it is possible to identify empirically-derived principles for engaging fishers that are associated with positive outcomes. These case studies are the efforts to reduce sea turtle bycatch in the US shrimp trawl fishery and dolphin bycatch in the US tuna purse-seine fishery. This research involved nearly 50 interviews and over 700 documents analysed with a grounded theory approach within the framework of theories on invention, diffusion of innovation, technology transfer, and expertise. I identify a common profile shared by fishers who invented successful bycatch eduction devices. Namely, they have extensive experience in fishing and fabrication and have the ability to mentally-model prototypes. The common hindrances in engaging fishers include: selecting fishers as partners based on convenience rather than relevant bycatch solving ability, differences in cultures of communication between partners, and failure to appropriately "court" fishers in accordance with their cultural norms. This presentation offers recommendations for how to identify potential partners that fit the Successful Fisher/Inventor Profile and how to initiate partnerships so as to avoid the common stumbling blocks.

7.3 New Zealand Bycatch issues

Facilitators: Emma Jones, (NIWA), Steve Parker (NIWA), Richard Wells, (Fisheries Inshore New Zealand and Deepwater Group)

Bycatch in New Zealand Fisheries – background and key issues

Dr Jeremy Helson*, (FINZ), Richard Wells* (FINZ and DWG) and Carol Scott (Southern Inshore Fisheries Management Co. Ltd)

Thirty years ago New Zealand embarked on a policy shift away from input controls and towards output controls in the form of property rights in fish stocks and a market that allowed transfer of catching rights either annually or in perpetuity (the Quota management System or QMS http://fs.fish.govt.nz/Page.aspx?pk=81). Many input controls such as mesh size regulations remained in place, but the incentives provided by the QMS were considered sufficient to drive research in the area of fishing technology and innovation. Direct government research capability in fishing gear and selectivity dwindled under this policy, and Industry was expected to resolve bycatch issues itself.

New Zealand's fisheries include demersal and surface longline, set-net, trap and pot, purse-seine and trawling (again demersal or pelagic). A large number (i.e. several hundred) of coastal trawlers and longliners are less than 28 m in length, and using gear and techniques that, mostly, have not changed significantly for some decades. These vessels operate in fisheries that encounter a wide mix of species, and have varying problems with bycatch. Deep-water fisheries can, at times have similar issues although the species mix is less "demanding". Longlining, especially at the surface for tuna and swordfish also has some problems, especially with regard to sharks, which are unwanted and a cost on operations, but hard to deter.

Similar to other fisheries world-wide, bycatch issues in NZ can be characterized into the following criteria;

- Juveniles of target quota species;
- Adults of quota species for which the allowable catch limit has been reached by the individual fisher or the fleet as a whole, becoming a choke species on other target stocks;
- Unwanted/Non-target catch, including non-marketable fish, invertebrates and other marine life;
- Protected (or threatened and endangered species) e.g. seabirds, marine mammals and reptiles, and some species of shark and rays.

Incentives driving development and adoption of gear technology to reduce bycatch in New Zealand include seeking certification under the Marine Stewardship or similar "ecolabel", an increased focus on environmental impacts, and the NZ Fisheries Act and Wildlife Act for protected species. This legislation has resulted in a significant emphasis on reducing captures of seabirds (NZ has one of the most abundant and diverse seabird populations in the world), as well as marine mammals including pinnipeds (seals and sea lions) and cetaceans (dolphin species. A combination of both local and international resources and knowledge has often been successful in the refinement or adaption to local conditions of techniques developed overseas. For example, the Sea Lion Exclusion Device (SLED) has its origins in both Atlantic cod bycatch reduction, and turtle excluder devices in the Texas shrimp fishery. This hard grid separation device has had significant success in reducing captures and mortalities of the NZ sea lion (*Phocarctos hookeri*). Considerable efforts have also been made to reduce trawl warp (cable) interactions with albatross (*Thalassarche* spp), and also common dolphin (*Delphinus* spp) captures in jack mackerel (*Trachurus* spp) pelagic trawl.

In all the fisheries concerned, independent observer coverage of reasonable scale has proven the improvements achieved fisheries (see relevant chapters in MPI 2016 Aquatic Environment and Biodiversity Annual Review online: www.mpi.govt.nz/document-vault/16339)

Some examples of problematic bycatch issues were presented to the group, with feedback sought;

- Yellowtail kingfish (*Seriola lalandi*) in jack mackerel trawl fisheries (a choke species).
    - Suggestions included the use of downward sorting grids (Haraldur Einarsson, Pieke Molenaar, and Steve Kennelly), or differences in behaviour (Mike Pol) and/or swimming endurance (Craig Rose) to avoid the larger bycatch species.
- Finfish and invertebrates in scampi (*Metanephrops* spp) fisheries.
    - Similar issues to the European scampi fisheries where significant research has been carried out, some of which was presented at the meeting. The differences in gear design were noted.
- Finfish and crabs in the squid trawl fishery
    - For benthic species, including crabs, the use of raised footropes, sweeps, and toggle chains was discussed (Paul Winger, Craig Rose), with the east coast US squid fishery notes as an example (Pingguo He and Mike Pol). In the NZ fisheries, the crab species include more active swimmers (paddle crab and red swimming crab), and there was a discussion about understanding swimming abilities and behaviour of these species (Pingguo He). The Spencer Gulf prawn trawl fishery uses a "crab bag" which consists of a large mesh bag inside the codend that separates out the crabs from the prawns, reducing damage to the target catch and allowing prompt discarding (Steve Kennelly?).
- Spiny dogfish (*Squalus acanthias*), skates and rays in inshore trawl fisheries
    - The use of an excluder grid in the silver hake fishery in Massachusetts Bay was given as an example, but some questions raised about whether it is currently in use (Mike Pol, Pingguo He). Alternative suggestion was to develop a market for the bycatch (Pamela Mace). Removing tickler chains were also noted as effective for reducing catches of skate (Pieke Molenaar). There was some discussion about issues with skates getting stuck when using grids, and one suggestion was the use of a long descending large mesh panel (Haraldur/Craig Rose). They were noted as a significant bycatch problem in some US scallop fisheries.
- Invertebrates such as sea cucumber in trawl fisheries for finfish.

- The use of benthic release panels, and electric pulse beam trawls in the North Sea was noted (Pieke Molenaar). A trawl designed to target sea cucumbers has also been developed in Australia (John Wakeford).

Industry-led efforts to reduce unwanted catch in a mixed fishery, Hawkes Bay

Emma Jones (NIWA)*, Oliver Wade (Hawkes Bay Regional Council), Rick Burch (skipper), Karl Warr (skipper), Derrick Parkinson (NIWA), Laws Lawson (Te Ohu Kaimoana), Jeremy Helson (Fisheries Inshore New Zealand), Alicia McKinnon (Ministry of Primary Industries).

The Hawkes Bay inshore trawl fishery consists of 14 fishing boats between 9 and 21 m which target a mix of species including gurnard (*Chelidonichthys kumu*), tarakihi (*Nemadactylus macropterus)* and a range of flatfish species. Concerns about the status of fish stocks in the Hawkes Bay, have led a number of fishers in this region to make a variety of modifications to their gear to reduce catches of undersized fish. These changes have included trialling different combinations of increased mesh sizes, T90 and square mesh sections, and development of more novel ideas, such as a rigid cage-style codend. These innovations have been, and continue to be largely self-funded, but recent support from Te Ohu Kaimoana, Fisheries Inshore NZ, MPI and NIWA has allowed some collaborative catch comparison trials and video observation to be carried out. The trials have followed an alternate tow approach, comparing the test net against an Industry "standard" trawlnet which includes a codend using the minimum legal mesh size of 4" diamond mesh. The use of 4" T90 mesh in the codend, combined with a 4" square mesh lengthener was highly effective at reducing catches of small gurnard (<30 cm) (61% reduction, $p < 0.05$), without affecting on catches of fish >32 cm. This configuration was not effective for elliptical shaped fish. Another skipper has developed a novel rigid codend, with panels that can be inter-changed depending on the species being targeted. With a 90 mm square mesh, a 90% reduction ($p < 0.001$) in sand flounder (*Rhombosolea plebeian*) less than the optimum landing size of 28 cm was achieved, with equal or greater catching efficiency to the diamond mesh codend at around 33 cm. For other species, including gurnard and red cod (*Pseudophycis bachus*) the reductions in catches were significant across a large part of the marketable length range, although the skipper can target these species more effectively using different panels. While the volume of catches is substantially less than from standard mesh codends, the improved quality and provenance of the product is achieving significant premiums from both a loyal local and a discerning global market.

The conclusion of the session was that many countries are grappling with similar issues and increasing imperatives to improve the "accuracy" of fish harvesting methods to improve stock and ecosystem sustainability and reduce waste. New Zealand has made considerable progress with resolving interactions with some protected species, and the benefit of international experience and research was evident in that process. Some voluntary uptake of simple changes such increased mesh size, T90 and square mesh have been shown to be effective for certain species, and other novel developments show promise for niche applications. It is hoped that connections made at the 2017 meeting will contribute to solving other bycatch issues in future.

Catching Up on Unwanted Bycatch in New Zealand

Richard Wells, Carol Scott, Jeremy Helson (richard@resourcewise.co.nz)

Prior to the introduction of New Zealand's Quota Management System (QMS) in 1986, there were dedicated resources for gear development. This focus on fishing gear reduced post-QMS for several reasons, most notably; an output-based management policy, a Government philosophy of "user pays", coupled with then relatively reduced abundance of some key stocks. For the last 15 years, there has been a renewed focus on gear technology, although most of this effort has been successfully directed to mitigating protected species bycatch as opposed to reducing unwanted fish bycatch. Most of our fish stocks have now rebuilt and the increasing focus of fishers, managers and the community has moved to the entire fishing operation from a wider sustainability perspective. This change of focus has led to a need for improved selectivity in some fisheries especially for trawl and longline. Attention is also turning to reducing the impact to the seabed from bottom trawling and dredging, all of which contributes to an ecosystem-based approach to fisheries management. Some recent areas of investigation include reducing the catch of invertebrates, juveniles of target species and market-size species for which the fisher has no quota. There are also issues with finfish bycatch in scampi fisheries (*Metanephrops* sp) and avoiding pelagic sharks in longline fisheries. This session will share some insights into our successes with protected species and seek feedback on where relevant research has been undertaken on issues that remain.

Industry-led efforts to reduce catches of small fish in a mixed fishery in Hawkes Bay, New Zealand

Emma Jones, Oliver Wade, Rick Burch, Karl Warr, Derrick Parkinson, Laws Lawson, Jeremy Helson, Alicia McKinnon (emma.jones@niwa.co.nz)

Concerns about the status of fish stocks in the Hawkes Bay, have led a number of fishers in this region to make a variety of modifications to their gear to reduce catches of small fish. These changes have included trialling different combinations of increased mesh sizes, T90 and square mesh sections, and development of more novel ideas, such as a rigid cage-style codend. This innovation has been, and continues to be largely self-funded, but recent support from Te Ohu Kaimoana, FINZ, MPI and NIWA has allowed some collaborative selectivity trials and video observation to be carried out. This presentation will give an outline of the results of these trials, which have demonstrated the success of both simple changes to the "standard" codend, and more novel developments. However, as with any mixed fishery, there are still challenges to achieving the desired release of all undersized fish!

7.4 Gear development

Quality driven gear development: Part I Fitting the process to the fish

Suzy Black (suzanne.black@plantandfood.co.nz), Gerard Janssen, Alistair Jerrett, Damian Moran

Evolution of fish harvesting technology has been largely directed by optimizing extraction selectivity, minimizing risk and maximizing capture efficiency. Because of the sustainable limits of the biomass our industry is now at the point where increased value can only come from maximizing resource utilization. To achieve this, we must be increasingly sophisticated about how we manage and harvest our limited resources. Fishing technology has evolved to the point where we are able to apply significant levels of control to the harvesting process, but where to apply the control to maximize value? Our group background in pre- and post-harvest physiology research strongly suggested that we move away from the mechanics of the fishing process and focus on fitting the process to the requirements of the fish. In the 1990's we sought out a model species to develop our understanding of the effects of harvesting on post-harvest quality. We settled on King salmon, an excitable aquaculture species that was experiencing harvest-related quality problems. From this research it was clear harvesting fish within their physical and physiological tolerances eliminated many quality defects and revealed surprising unexplored properties of the tissue. The success of this fish-centric, quality-focused, rested harvesting process gave us the confidence to apply the same approach to New Zealand's largest wild fishery (hoki). This presentation will look at the background and development of the Modular Harvesting System (currently being commercialized within the PGP Precision Seafood Harvesting programme) and how fish-focused industrial fishing technology is not only feasible but great business.

Quality driven gear development: Part II Technology in operation

Gerard Janssen (gerard.janssen@plantandfood.co.nz), Suzy Black, Alistair Jerrett, Damian Moran

Quality-driven trawl gear development puts the needs of the fish first: the harvesting process is fitted to the fish and not the fish to the process. Development of the Modular Harvesting System (MHS) has focused on delivering low-damage, low-fatigue capture of wild fish and the unharmed escape and release of unwanted catch. Commercialization of this technology is at the centre of the Primary Growth Partnership funded Precision Seafood Harvesting (PSH) programme. The MHS replaces the conventional mesh lengthener and codend gear of a trawl. It is designed to be fish friendly with a low flow and low turbulence in-trawl environment that is within the physiological tolerances of the target and non-target species. This allows fish to regain control, individualise and take care of themselves, allowing the catch to be landed with minimal damage and reduced fatigue, maximizing post-harvest opportunity and extracted value. We believe that adaptable, fish focused fishing technology is in its infancy with the MHS at the very beginning of allowing technologies designed around fitting the wild harvesting process to the fish. This presentation will look at the underlying principles behind this fish-centric design, the in-trawl environment and fish behaviour within the MHS and a comparison with mesh terminal end trawl gear.

Australian research to reduce bycatch, habitat impacts and fuel usage via Low Impact Fuel Efficient (LIFE) penaeid trawls previous work and next steps

Steve Kennelly, Matt Broadhurst (steve.kennelly@icic.net.au)

Australian scientists and fishers have researched ways to ameliorate unwanted bycatch and discards from penaeid ('prawn' or 'shrimp') trawls for several decades. In addition to developing various square-mesh panels and grids in and around codends (the traditional location for such modifications), in recent years, we have also been exploring ways to reduce bycatch via modifications to the anterior trawl. This work has been done under the additional goals of reducing both habitat impacts and drag (and therefore making trawls more fuel efficient). This presentation summarizes the work done so far, highlighting the need to consider all parts of the trawl when trying to minimize unwanted environmental impacts. We also summarize a recent national workshop involving Australia's penaeid-trawl industries which developed future directions to be taken in this area. The workshop highlighted the need for a national "roadshow" to extend the array of options currently available (and recently developed) to Australia's trawl fishers, netmakers and vessel owners. Then, individual fisheries will be encouraged to select, scientifically trial and modify appropriate options to use in their respective fisheries.

Performance of bycatch reduction devices varies for chondrichthyan, reptile, and cetacean mitigation

John Wakeford, Corey Wakefield (johnwakeford@fishinguntangled.com.au)

To improve bycatch mitigation of chondrichthyans, reptiles and cetaceans for a tropical demersal fish-trawl fishery, species-specific responses to bycatch reduction devices (BRDs) were investigated using both *in situ* subsurface and on board observations. There are few, if any, studies that have determined mitigation performances of BRDs from subsurface interactions for these species, as most are rarely encountered and thus require substantial levels of observer coverage for robust assessments. This study combined in-net and on board (774 day-trawls and 1320 day-trawl hours of subsurface observer coverage) electronic monitoring on all fish- trawl vessels (n 1⁄4 3) to compare bycatch mitigation performances among nine megafauna groups, based on escape rates and interaction durations for three BRDs over 6 months (June to December 2012). Overall, 26.9% of day trawls had no megafauna interactions and 38.3% of the 1826 interactions escaped, with most in rapid time (91.4% in 5 min). The upward inclined exclusion grid significantly improved the escape proportions for most chondrichthyans by 20–30%. All BRDs were highly effective in reducing reptile (turtles and seasnakes) bycatch, but irrelevant to the few sawfish (n1⁄413) that readily entangled in the anterior of the net. Cetacean (bottlenose dolphins only) interactions with BRDs were very rare (n1⁄47) despite high levels of attendance and depredation during trawling. Loss of targeted teleosts through the BRD hatch was rare (1.3% of day trawls). This relatively cost-effective method of electronic monitoring achieved very high levels of subsurface observer coverage (60% of day trawls or 56% of day trawl hours), and provided evidence that the subsurface expulsion of megafauna in poor condition is negligible. Furthermore, this study provides species-specific improvements toward bycatch mitigation strategies for demersal fish trawling.

7.5 Technology for efficient and selective harvesting of crustaceans

Automated valves for measuring discards in demersal fisheries

Pieke Molenaar, Michiel Dammers, Ruben Verkempynck (pieke.molenaar@wur.nl)

The Dutch large cutter fleet operating in the North Sea consists of three segments: a beam trawl, twin-rig, and *Nephrops* fishery. Cutters within this fleet differ in vessel length overall (23–40 m), engine power (223–1491 kw), beam length (4–12m), mesh size (70–120 mm), haul duration (1.5–6 hours), catch quantity (up to 4000 kg per haul), and catch processing time (30–45 minutes). The high quantities of catches per haul can only be processed in an efficient way through semi-automatic sorting and processing machinery on board of the fishing vessels. These high catch volumes subsequently result in high discard rates. The beam trawl fishery is responsible for the biggest quantity of discards. In the period of 2011–2013, an average of 56 000 tonnes per year were discarded. For the biggest beam trawl vessels discard rates reach up to 74%. These rates are exceptionally high and in the 'danger zone' where small uncertainties in the estimation have a disproportionately large effect on raised discard quantities. In the Dutch discard monitoring programme, the total catch volume per haul is estimated by the skipper and the scientific observer. There are several methods to quantify the catches of the cutter fleet in the North Sea. These methods and their pros and cons are presented in this paper. The total volume of discards from each haul is then calculated by subtracting the weighed total landings from the estimated catch volume. Several of these methods are evaluated here and analysis has shown that catch estimations vary substantially between methods. To prevent these inaccurate estimations a solution for the cutter fleet in the North Sea can be found in the use of automated discard valves. A solution to accurately weigh all the catch that would fall through the discard valves. The valves are designed to fully automated measure quantities falling through the shaft. It opens and closed two separated programmed valves so that all fish, benthos and debris is measured in weight. The first prototype has been developed and tested.

SepNep multispecies selectivity in *Nephrops* trawls by combining innovative sorting panelsand grids

Pieke Molenaar, Juan Santos, Kees van Eekelen, Daniel Stepputtis, Josien Steenbergen, Jan Jaap Poos (pieke.molenaar@wur.nl)

Multi species fisheries targeting *Nephrops* are known for large quantities of bycatch, and the European Landing obligation (LO) requires all catches of regulated commercial species onboard to be landed. With the LO the current *Nephrops* fishery is challenged to develop selective trawls as it becomes unprofitable. The SepNep concept was developed to sieve *Nephrops* into a lower codend, while guiding fish towards a large mesh upper codend. To mitigate nonmarketable *Nephrops* catches an innovative grid was mounted in the lower codend. Under commercial conditions the experimental trawl produced 65% less discards. However, a small loss of marketable *Nephrops* was found and further improvement was necessary for commercial application. Four SepNep designs in a commercial *Nephrops* trawl were tested with a third codend attached to the rear of the grid to measure fish and *Nephrops* passing through. All three codends were blinded to retain the separated fractions of the catch. SepNep1 and 2 were considered successful and tested for multiple hauls. By improving the SepNep design the sorting panel sieved 87% of the marketable *Nephrops* to the lower codend. Flatfish selection curves were strongly dependant on fish length, but most of the undersized individuals were guided to the upper codend. The results of the grid demonstrated a steep and precise size selection curve for *Nephrops,* allowing 56% of the non-marketable *Nephrops* to pass. The results demonstrate the potential for this SepNep concept and will be a step forward in implementing and acceptance of the EU LO by the *Nephrops* fisheries.

FLEXSELECT: a flexible counter-herding device to reduce bycatch in trawl fisheries

Valentina Melli (vmel@ aqua.dtu.dk), Junita D. Karlsen, Jordan F. Feekings, Bent Herrmann, Ludvig A. Krag

The landing obligation (discard ban) introduced as part of the European Union's (EU) Common Fisheries Policy (CFP), together with an increasing shift towards Individual Vessel Quotas, resulted in a growing need to modify gears selectivity and reduce unwanted catch. We designed and tested a flexible and simple counter-herding device, FLEXSELECT, aiming at reducing bycatch of fish by scaring them away from the trawl path. As a case study, we chose the Norway lobster (*Nephrops norvegicus*) directed fishery, as it includes bycatch of both roundfish and flatfish. The efficacy of the device was tested in a twin-trawl system. Length-based catch comparison analyses were conducted on seven species (Norway lobster, four roundfish and two flatfish species). FLEXSELECT reduced the overall catch of fish by 41% (CI: 31–48%), and the number of individuals above MCRS (Minimum Conservation Reference Sizes) were reduced by 51% (CI: 41–59%). The intensity of the effect varied among species and was strongly length-dependent for most roundfish species. No significant effect on the target species, Norway lobster, was detected. Separate analyses were performed for day and night hauls and no significant differences were found in

FLEXSELECT effects for either roundfish or flatfish species. FLEXSELECT was easily mountable and de-mountable on a haul-by-haul basis and substantially reduced the bycatch of fish species, providing a simple efficient tool to optimize catch compositions under e.g. a landing obligation system.

Utilizing differences in behaviour to improve catch efficiency in the *Nephrops* directed fisheries

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Of the fisheries in the Northeast Atlantic the *Nephrops*-directed fisheries are among the most important fisheries economically. Several of these fisheries are highly mixed fisheries where different fish species are targeted together with *Nephrops*. In this study we redesign a standard North Sea *Nephrops*-directed trawl by covering the standard 120 mm in the trawl body and the 140 mm meshes in lower wings with 90 mm meshes. The standard and the experimental gears were fished in parallel using a twin-trawl system and catches was analysed using the catch-comparison technique. The catch of *Nephrops* larger than the minimum conservation reference size (32 mm carapace length) increased significantly by 43% using the experimental design without any effect for cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and hake (*Merluccius merluccius*). These results demonstrate that the catch-efficiency in the *Nephrops*-directed trawl can be improved substantially by reducing the mesh size in the lower half of the trawl while the upper half can likely be increased as fish seem to avoid direct contact with the netting in the belly section of the gear.

Selectivity in a divided codend used in the multispecies trawl fishery targeting crustaceans

Junita D. Karlsen (jka@aqua.dtu.dk), Ludvig Ahm Krag, Bent Herrmann, Henrik S. Lund

The incentives for developing selective fishing gears increase globally with increasing demands for sustainable fisheries. A major challenge in mixed trawl fisheries targeting crustaceans is reducing the high level of unwanted catch. We tested the selectivity of fish and *Nephrops* in a divided codend with 120 mm and 60 mm square meshes in the upper and lower compartments, respectively, towed in parallel with a divided codend made of 40 mm square meshes using a commercial vessel with a twin-rig. We analysed the selectivity of the compartments separately and combined for eight species. The selectivity was higher in the upper than the lower compartment. For cod and haddock, the combined selection curves showed a pattern with relatively high retention for small sizes, decreasing for medium-sized individuals, and raising towards full retention for larger individuals due to the size-dependence of the proportion of individuals swimming into the upper compartment and escaping through the larger meshes. Hake and flatfish preferred the lower compartment. The mismatch between the square meshes and the body shape of flatfish explain the full retention of all sizes in the lower compartment and the low selectivity in the upper compared with roundfish. No retention of *Nephrops* was observed in the upper compartment. The combined selectivity curve was close to that of the lower, preferred compartment. The majority of fish and *Nephrops* can be separated and subsequently subjected to different selectivity. Separated codends can easily be changed with similar codends of other mesh types to optimize the selectivity in mixed fisheries.

CREELSELECT: a method for selecting optimal creel mesh for Norway lobster (Nephrops norvegicus, (L.))

Jure Brčić, Bent Herrmann, Marina Mašanović, Mateja Baranović, Svjetlana Krstulović Šifner, Frane Škeljo (jure.brcic@unist.hr)

In the Mediterranean Sea, *Nephrops* (*Nephrops norvegicus*) is predominantly caught with bottom trawls, but it is also harvested with creels. Since the size selection of *Nephrops* in bottom trawls is well documented, and there is no previous information on creel size selection for this species, sea trials were carried out to assess the selective properties of commercial creels with 40 mm mesh size netting mounted as square mesh netting as prescribed by the legislation. The average carapace length of a crustacean with a 50% probability of being retained (L50) was 31.76 mm. Furthermore, in the laboratory, we investigated what sizes of *Nephrops* could pass through the meshes of different size and shape to establish a predictive model for size selectivity in creels. Predictions agreed well with the results from experimental fishing, demonstrating the reliability of this simple method. Our model provides an easy and quick method to identify optimal mesh size and shape without having to rely on exhaustive sea trials with various creel designs. The method can easily be adapted to other species and creel fisheries to help selecting optimal mesh matching a prescribed exploitation pattern.

Addressing the Challenge of Bait Intensive Fisheries: Can Alternative Baits Work in the Barents Sea

Tomas Araya Schmidt (Tomas.Schmidt@ mi.mun.ca), Olsen, L., Rindahl, L., Larsen, R., and Winger, P.D.

Commercial harvesting of snow crab (*Chionoecetes opilio*) in the Barents Sea started in 2014 by Norwegian and Russian fishing vessels. This new fishery has significant bait requirements, representing an emerging conservation challenge. In this study, we evaluated the performance of alternative natural baits manufactured from meat by-products. Five different types of new bait were tested; bait 1, bait 2, bait 3, bait 4, and bait 5. Experimental pots baited with these new baits were randomly distributed in commercial fleets of pots and control pots were baited with whole squid. No significant differences were found in the count of crabs between bait 1 and squid, while all other bait treatments differ significantly in the number of crabs per pot hauled. Pots baited with bait 1 caught 45% more crabs, while, baiting pots with bait 2, bait 3, bait 4, and bait 5 decreased mean cpue between 25% and 81%. High variability of cpue was observed along the experiment, standard deviation ranged from 2 to 12.9 with a total mean value of 8.1. Mean CW and frequency distribution of CW was statistically the same across categories of bait indicating that alternative baits tested had no effect on snow crab size.

Assessments of Species- and Size- Selectivity of Bycatch Reduction Devices for Shrimp Beam Trawl

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This study describes species- and size-selectivity of Bycatch reduction devices was developed to avoid bycatch of juvenile fish smaller than marketable size and small crabs of no-marketable in a shrimp beam trawl. This device is comprised of pair of net panels (front panel(FP) with square mesh of 80 mm mesh size, rear panel(RP) with diamond mesh of 27.5 mm mesh size) and two fish vents and was installed on the bottom part of net-mouth. In this study, Authors have developed two kinds (proto type and improved type) of bycatch reduction device. The mean height of the improved BRD was about 1.7 m, which is much higher than 0.4 m height of proto BRD. Therefore, the probability of encountering Lizardfish and Cinnamon flounder became higher, achieving more effective size separation of these species by mesh selectivity of the FR. While small crabs were eliminated through the vent after passing through the FP, smallest shrimps, which were the main target species, were caught. In this study, numerical models for expressing available selection by the Bycatch Reduction Device were proposed and assessed in several fishing experiments conducted using two type of Bycatch Reduction Device. Contact probability and selectivity parameters of the FP and RP for four species were estimated for each Bycatch Reduction Device type.

7.6 Means and methods to mitigate bycatch, discards, and seabed impact

Quantitative analysis of species selectivity of fishing gears an ecological approach

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This presentation explores a quantitative method for analysing species selectivity of fishing gears using data from trials of a separator haddock trawl *Rope Separator Trawl, or RST) as an example. Fishing gears can be considered as predators to aquatic animals, thus resource selection theory and related analytical method in ecological studies, such as selective predation strategies, can be applied for quantitative analysis of species selectivity. Various theories and approaches in selective predation were evaluated, and Vanderploeg and Scavia's electivity index, here we call it "Species selection index", was found suitable for evaluating and comparing species selectivity of fishing gears, especially towed fishing gears. For the Rope Separator Haddock (RSH) trawl, the gear was positively selective for haddock (*Melanogrammus aeglefinus*), and negatively selective for American plaice (*Hippoglossoides platessoides*), yellowtail flounder (*Limanda ferruginea*), American lobster (*Homarus americanus*), and skates (*Raja* spp), but was non-selective for Atlantic cod (*Gadus morhua*) and spiny dogfish (*Squalus acanthias*). This is the first attempt that resource selection theory and analytical methods are being applied in species selectivity analysis of fishing gears and may provide a new means for analysing and comparing species selectivity among different gear designs and gear types, and in different areas or seasons.

Avoidance of Atlantic cod (Gadus morhua) with an ultra-low opening trawl (ULOT) in the New England groundfish fishery

Michael Pol, Stephen Eayrs, Jon Knight, Jim Ford (mike.pol@state.ma.us)

Avoiding or preventing entry of eventual discards into a trawl is a logical approach to reduce mortality from capture or potential injury and risk of post-escape mortality. In multispecies trawl fisheries, observations of behaviour of individual species or stocks can suggest design modifications to increase avoidance or prevent trawl entry. In US waters of the northwestern Atlantic Ocean, Atlantic cod (*Gadus morhua*) quotas in the groundfish fishery have fallen to historic lows and consequently restrict fishing for stocks of groundfish in healthier condition. A collaborative team of fishers, net builders, and gear technologists, building on previous studies of cod avoidance, observations of cod in front of trawls, and fishing experience, developed several prototype cod-avoiding trawl designs. These designs were numerically and/or physically modelled; all sought to avoid herding of cod in the mouth of trawls or to minimize headrope height. One design, the Ultra-low Opening Trawl (ULOT), was selected by consensus based on modelling results and practicality. This trawl, with a headrope length 10% longer than the footrope, and vertical opening of 0.6 m, was tested against a standard flatfish trawl design in May-June 2016 as a potential option for passing below cod while fishing for flatfish. A total of 67 hauls with 31 valid haul-pairs were completed in the Gulf of Maine, USA. Six species/species groups (American plaice *Hippoglossoides platessoides*, Atlantic cod, yellowtail flounder *Limanda ferruginea*, witch flounder (grey sole) *Glyptocephalus cynoglossus*, American lobster *Homarus americanus*, and unclassified skates, *Rajidae*) comprised 92% of the total catch by weight. Catch rates of Atlantic cod were significantly reduced using the ULOT, by an average of 42.6 kg h^{-1} or 45.2%; catch rates of the five other species were not found to be different, except for catches of small American plaice (<30 cm); these catch rates were reduced by 27.9%. The ULOT may be considered as a potential option, along with the recent results from topless trawls, for fishers to avoid cod with little harm and to access flatfish quotas.

New Approaches to Seabird Mitigation in Australian Trawl Fisheries

Phil Ravanello, Josh Cahill, Simon Boag (phil.ravanello@afma.gov.au)

The Southern and Eastern Scalefish and Shark Fishery (SESSF) is the largest Australian Commonwealth managed fishery by tonnage, and covers nearly half of the Australian Fishing Zone. Within the SESSF there are two trawl sectors, South East Trawl (SET) and Great Australian Bight Trawl (GAB). These are multi species trawl fisheries which are fished by small trawlers (15–30 m in length) without freezing capacity. Like most trawl fisheries, the SET and GAB trawl fisheries have a level of interaction with seabirds. Since 2014, trawl vessels operating in these fisheries have been required to use 600 mm windy buoys attached to each warp so that seabirds are deflected from warp strikes. During 2014–2015, the Australian Fisheries Management Authority (AFMA) in conjunction with the South East Trawl Fishing Industry Association (SETFIA) undertook trialling of bird bafflers on demersal trawlers. The bird bafflers trialled are a modified version of what is currently used in NZ (Brady and Burka bafflers), but designed for smaller vessels. Results demonstrated a significant reduction in warp strike when compared to warp deflectors. Subsequently, AFMA has mandated the use of bafflers as an approved mitigation device from the commencement of the 2017 fishing season (1 May). This presentation will describe the technical aspects of the bird baffler project, as well as the roll out of this device across the trawl sectors. There are also some valuable take home messages in this presentation about change management in fisheries which may be of some use to conference participants.

Effect of the inner netting on the physical performance of Antarctic Krill trawl

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In order to understand the effect of the inner net on the physical performance of the Antarctic krill trawlnet, a model test was conducted using the circulating tank of Tokyo University of Marine Science and Technology following the Tauti Model rule. 4 level of inner netting area, 5 level of towing speed and 5 level of L/S were tested with the following main results: 1) Net resistance increased with the twine area of inner netting. Its increase rate was small at low speed and increased with the towing speed. 2) Net mouth opening reduced as inner netting twine area increases. With towing speed increase, its reduction rate slowed down as the inner netting twine area increased. When $L/S \leq 0.45$, change in inner netting twine area has less effect on net mouth opening, but the change in net resistance has more effect. When $L/S > 0.45$, the change in the inner netting twine area had some impact on the net mouth height, and the difference in the net mouth height became bigger as increase of speed, the maximum difference was 3 m. The change in both net resistance and mouth height were very small when the inner netting twine area account for 9.27% the main body. 3) When L/S ≤ 0.45 and towing speed higher than 2 Kn, the inner netting twine area reduction resulted in reduction of the energy consumption coefficient. When L/S > 0.45, the change in energy consumption coefficient was small when the inner netting twine area increased from 16.93% to 23.24%.

Survival of trawler deck-released halibut as observed with tilt-sensing satellite tags

Craig S. Rose, Julie Nielsen, Timothy Loher, Suresh Sethi, Andrew Seitz, Paige Drobny, John Gauvin, and Michael Courtney (fishnextresearch@gmail.com)

Under existing catch handling regulations for Bering Sea trawl fisheries, trawl-caught halibut cannot be released prior to observer sampling in vessels' fish processing factories. The resulting delayed release produces high halibut discard mortality rates. In response, trawlers are working with NMFS to develop methods to quickly sort and release halibut from catches on deck, while accounting for their numbers, size, and viability. To evaluate expedited release efforts, information on the survival of released halibut is needed. Satellite tags have been used to monitor survival of fish that swim continuously (sharks, tuna), where swimming cessation indicates fish death. Because halibut periodically remain motionless for extended periods, using (in) activity signatures to detect death is a considerable challenge. We worked with Wildlife Computers to develop particular activity recording metrics for the Halibut-sPAT tag. These tags reported summarized accelerometer data to monitor halibut survival by tracking fish activity behaviours. Trawl taken as bycatch halibut are smaller than halibut previously studied with satellite tags, raising concerns that tags could affect halibut performance and survival. In summer 2016, one hundred and sixty halibut were tagged with Halibut-sPAT tags during deck release from three trawlers targeting flatfish in the Bering Sea. Tags reported two-hour summary values of the number of rapid increases in tag tilt (swim starts) and the percentage of time tags tilted beyond a prespecified threshold (swimming %) while attached for up to 60 days. Ten longline- caught halibut selected to be in excellent condition were tagged to characterize 'natural' fish activity. We also tagged 6 seafloor anchors and 4 halibut carcasses, providing sedentary or carcass-based tag metrics. Data patterns from these reference tag sets provided context for survival interpretation of tag data from trawl releases. Challenges in distinguishing survival/death from other outcomes (e.g. tag loss) are discussed and indicated survival outcomes are compared to viability-assessments, fish size, capture and handling metrics (e.g. catch size, time-on-deck), and variability between vessels and fishery targets. Preliminary results from 2016 deployments indicate that satellite-tagging with accelerometer data can be a viable method to evaluate release survival for an important flatfish species with frequently sedentary behaviour.

Movement range and behaviour characteristics of *Gadus macrocephalus* in Jinhae Bay, Korea

Hyeon-Ok Shin, Min-A Heo, Gyeom Heo (shinho@pknu.ac.kr)

In order to collect basic information of migration of Pacific cod (*Gadus macrocephalus*), the behaviours of Pacific cod during winter in Jinhae Bay, Kore were investigated. Three wild fish C1 to WC3; total length 72.3 ±5.5 cm; body weight 3.03 ±0.38 kg) were tagged with the acoustic tag. WC1 was tagged with an acoustic tag internally by surgical method. WC2 and WC3 were tagged externally with the acoustic and a micro data logger for recording audible sound waves including timer release unit. The movement routes of the tagged fish were tracked more than 5 hours using VR100 receiver and a directional hydrophone. Three tagged fish were individually released on the sea surface around the entrance to the Jinhae Bay on 10 to 24 January 2015. WC1 was moved about 13.32 km with average swimming speed of 0.63 m/s during 6 hours. The average swimming depth and water depth of the seabed on the route of WC1 were 7.2 m and 32.9 m, respectively. WC2 and WC3 were moved about 7.95 km and 11.06 km with average swimming speed of 0.44 m/s and 0.58 m/s during 5.1 and 5.3 hours, respectively. The average swimming depth of WC2 and WC3 were 18.7 m and 5.0 m, and the water depth on the route, 34.4 m and 29.8 m, respectively. Consequently, three tagged fish were commonly moved toward outside the entrance and headed for eastward of the Korean Peninsula whereas toward inside of the Bay during 1.5 to 3.0 hours, approximately, after releasing.

Quantifying Seafloor Contact in Commercial Fishing Gear

Brianna Bowman King, Bradley Harris, Craig Rose (bking@alaskapacific.edu)

All of the commercial fishery species harvested globally either live on or near the seabed (also referred to as the benthos or benthic environment) or employ life-history strategies or behaviours which are linked to benthic processes. The act of pursuing and catching benthic and demersal ('near the bottom') species requires operating fishing gear on or very near the seabed, resulting in direct gear-seabed contact. It is essential to further quantify bottom contact, given that contact made by commercial fishing gear with the benthos is considered one of the most significant human impacts on the oceanic environment. There are a few devices that measure bottom contact; these devices usually address only one point of contact, such as the center of the footrope, when other components of the fishing gear may be making contact as well. An NPRB-funded study by Rose *et al.* (2016) used multiple bottom contact sensors (accelerometers) hung from the footrope of a trawlnet to quantify bottom contact. The authors of this study provided statistical analyses of the gear configurations as they relate to habitat susceptibility; examination of components, material and clearance was beyond the scope of the work. Here I propose an algorithm to examine these covariates as estimators of habitat susceptibility by reassessing the data from the field, constructing quantitative models based on these covariates, re-running the applicable models, and examining the spatial distribution of seabed clearance for each material and component combination. These data, along with an assessment of the current state of science and technology in bottom contact sensors, will help determine the best method of bottom contact measurement to be used in future lab-based and field-based portions of this study.

7.7 Topic group meetings

Three presentations were given before the topic group meeting started. The last presentation from last day and those three were connected to the work within this year ToRs.

Fishing effects in 3D – it's not all about bottom contact anymore

Aileen M. Nimick (animick@alaskapacific.edu), Bradley P. Harris, Craig S. Rose, T. Scott Smeltz, Suresh A. Sethi

The Magnuson-Stevens Fisheries Conservation and Management Act of the US mandates that fisheries management councils minimize adverse fishing effects to essential fish habitat. The National Research Council has identified three fishing effect mitigation tools – harvest reduction, habitat closures, and gear modifications. The New England and the North Pacific councils have created mathematical models that estimate fishing impacts to the seabed to support the determination of whether the impacts are considered adverse, the other fisheries councils use qualitative approaches. Ideally fishing effects models should be able to assess the relative efficacy of these three management tools. The New England and the North Pacific models can examine impacts associated with changes in harvest levels and the use of area closures; because they assess habitat impacts in a two-dimensional (width X distance) framework they are limited in their ability to incorporate information about gear modifications. We are creating a generic three-dimensional component-specific model for estimating habitat disturbance, adapted from the North Pacific Council's Fishing Effects Model. We are modifying the model framework to include component-specific fishing gear information in three dimensions, and the habitat feature susceptibility groups to account for feature height. Using Alaska's sweep modified trawls as an example, the first iteration of the three-dimensional model estimated similar habitat disturbance as the two-dimensional. Exploring different susceptibility values should cause the two models' estimates to diverge. These results will be presented in this talk.

E-Audit: Energy performance evaluation for Mediterranean trawler

Emilio Notti (e.notti@an.ismar.cnr.it), Antonello Sala

The prospect of sustained high fuel prices has provoked widespread interest in finding energy efficiency strategies to mitigate the overall impact to the fishing sector. Energy efficiency must be the result of a methodological approach. A continuous monitoring of vessel energy performance thorough a periodical investigation allows to identify increasing in energy (fuel) consumption, reacting to solve as soon as possible. An Energy Audit tool were conceived at CNR–ISMAR of Ancona. For each vessel monitored, through a preliminary interview to the owner, technical information was collected. On the basis of the energy layout obtained from technical information, the measurement kit was prepared for monitoring fuel consumption, power delivered, speed and course, gear drag, hydraulic and electric power usage. The energy audit proposed is organized in several steps: 1) a preliminary interview to fisher allows to collect information about vessel characteristics such as vessel size, power installed on board, propulsion system characteristics, target species, activities on board, information about the crew, machinery on board etc. the interview is carried out using a devoted checklist; at the same time, inspection on board is needed to assess the availability to install and set up measurement kit; 2) Installation and calibration of measurement kit according to vessel characteristics and metrics; 3) During normal fishing activities, energy users are monitored by a surveyor through a data collection software. A registry event is compiled in order to relate specific energy usage to different events (sailing, trawling, hauling, searching phases); 4) Data acquired are elaborated to define the energy consumption and the energetic profile of the vessel by calculating Energy Performance Indexes. The result of collected data processing is the energetic profile of the vessel. Once the energetic profile is defined, it is possible to identify the most-demanding energy users and to further investigate on possibility to reduce energy usage and fuel consumption. Through energetic performance indicators, fishing vessel is characterized during trawling and sailing phases. Energy Audit carried out highlighted low propulsion system efficiency, typically with a fixed pitch propeller, especially during trawling for pelagic pairtrawlers.

Technological advances of fishing lamp and energy saving effect in the squid jigging fishery

Heui-Chun An (anhc1@korea.kr), Jae-Hyun Bae, Hyun-Young Kim

Squid is an important species with a world capture production of 1.29 million tonnes in 2014, and jigging is one of the major fishing methods in the squid fishery. The fishing lamp plays an important role in the squid jigging, and the performance of fishing lamp is steadily improving from torch, oil lamp, incandescent lamp, metal halide lamp to LED lamp. Fishers are increasing the capacity of fishing lamp to collect fish schools effectively. On the other hand, there is a concern that the capacity of fish attracting lamps is excessive, and studies are underway to reduce energy consumption. In this presentation, we will review the development history of fishing lamps, energy saving, behavioural habits of squid to fishing lamps and discuss the future prospects.

7.8 Fisheries and gear technology in Kenya and Tuna fishery

Capture fisheries studies in Kenya

Yoshiki Matsushita (yoshiki@nagasaki-u.ac.jp), Khyria Swaleh, Xiaofeng Ou, Monica Owilli, Keiko Kito

Several research studies on traditional fishing performance in Lake Victoria and North Coast of Kenya were conducted. In Lake Victoria, seining is a major activity using fish aggregating lamp to catch *Rastrineobola argentea*, Silver cyprinid. Daily catch and behaviour of four fishing boats were monitored. GLM analysis revealed that catch of silver cyprinid is significantly affected by use of outboard motor, lunar phase and seasons. Daily catch amount by motorized boats was greater than paddled boats, but catch per haul of motorized boats was less than paddled boats. Outboard motor allows fishers to shoot more nets per day and access distant waters, but engine noise may scatter the fish aggregation. In the North Coast, seining is also a major fishing activity. SELECT analysis, to estimate size selectivity of 1.5′ and 1.75′ mesh sizes, was performed for major species *Leptoscarus vaigiensis, Siganus sutor* and *Lethrinus lentjan* with assuming 1′ codend as a control. Size selectivities of 1.5′ and 1.75′ for *L. vaigiensis* and *S. sutor* were not different. 50% retention lengths of 1.5′ and 1.75′ codend for *L. vaigiensis* ranged between 14.0 cm and 15.7 cm, *S. sutor* between 8.8 cm and 9.8 cm. Selectivity for *L. lentjan* of 1.5′ codend showed dull curve suggesting selectivity similar to the control codend. These fish retained in codends of 1′, 1.5,′ and 1.75′ are still immature individuals when 50% maturity sizes are referred by Fish Base (www.fishbase.org). Gear technology is necessary to manage Kenyan fisheries.

The tuna fisheries of mainland China fisheries status, challenge and strategies

Liming Song, Yukun Qi (LMSONG@SHOU.EDU.CN)

The tuna fisheries status of mainland China were reviewed in this presentation. The fishing capacity of tuna fisheries of mainland China was expanded. There were 542 tuna fishing vessels legally registered in the four regional tuna fisheries organizations in 2015. Coordination and service capacity of China fisheries administrative authority have been significantly improved. The challenges in the tuna fisheries of mainland China are as follows: (1) The resources of targeting species are declining; the fishing capacity is too large; (2) The profits of the industry are falling; (3) The recruitment of fisher engaged in distant water fisheries is decreasing; (4) The technical level of the fisher is declining; (5) The capacity to comply with the international regulation needs to be improved. The following strategies are proposed: (1) The fishing capacity should be reduced in the near future;(2) The impacts of the climate change should be studied to understand the fluctuation trend of the fishing ground and improve the fishing efficiency; (3) The profits of the industry should be increased by improving the management, employing the foreign fishers, using the energy saving fishing strategy, etc. (4) The recruitment of fisher engaged in distant water fisheries should be increased by enacting decrees of early retire; (5) The technical training should be implement to improve the fishing technical level of the fishers; (6) The capacity to comply with the international regulation should be improved by heavy training; (7) The electronic logbook and camera system should be used to reduce the monitoring cost.

Prediction the shooting trajectory of tuna purse-seine for an unassociated fish school

Chun-Woo Lee (cwlee@pknu.ac.kr), Jihoon Lee, Subong Park

Purse-seine fishing is a very effective method to catch large volumes of fish. It is used especially often for catching tuna a fish with high added value. In order to get a successful catch in purse-seine fishing, it is important to choose the initial shooting position based on the speed and direction of the target fish, and the speed of the ship. In the field, the initial shooting position typically depends on the experience of the captain. However, with regulations about fish aggregating device (FAD) schools becoming stricter worldwide, a more precise shooting trajectory is required to improve the catch success rate for unassociated schools. This study aimed to improve the catch success rate in purse-seine fishing of unassociated schools. In this study, we propose the trajectories with high possibility of operation for purse-seine fishing according to the speed and direction of the fish school. In particular, two methods for the gear setting are proposed according to the speed of fish. The first gear setting method with the condition is that the fish meet the center of the gear when the fish move without changing direction, and the second one can be applicable to the fast-swimming schools. In addition, when the covered depth by the sinker line can be known through the analysis of the gear behaviour, the trajectory of the gear setting is suggested according to the depth of the sinker line. The results from this study could be used as a technological alternative to reduce FAD operation, which is an international problem for tuna resource management and to reduce the catch of non-target species.

Hydrodynamic characteristics of tuna purse-seine netting panels with different knot types

Hao Tang (tanghao812@126.com), Liuxiong Xu, Fuxiang Hu

Nylon netting (PA) is widely used in purse-seines and other fishing gears due to its high strength and good sinking performance. However, the hydrodynamic properties of nylon netting of different characteristics are poorly understood. This study aims to investigate hydrodynamic characteristics of nylon netting of different knot types and twine characteristics and under different attack angles and flow velocities. It was found that the hydrodynamic coefficient of the netting panels was related to Reynolds number, solidity ratio, attack angle, knot type and twine construction. The solidity ratio was found to positively correlate with drag coefficient when the netting was normal to the flow (CD90), but not the drag coefficient when the netting was parallel with the flow (CD0). For netting panel inclined to the flow, the inclined drag coefficient increased as solidity ratio decreased at attack angle was less than 50°, but increased as solidity increased at attack angles from 50° to 90°; the lift coefficient increased with the attack angle, reached the culminating point at an attack angle of 50°, and subsequently decreased. We found that the drag generated by knot accounted for 15–25% of total drag, and the knotted netting with higher solidity ratio exhibited a greater CD0, but it was not the case for the knotless netting. Compared to knotless polyethylene (PE) netting, the drag coefficients of knotless PA netting were dominant at higher Reynolds number (Re>2200).

8 Topic Group: Change Management in Fisheries (Change)

Conveners: Steve Eayrs (USA) and Mike Pol (USA)

This report represents the culmination of the topic group over the past three years, and therefore is considered the final report of the Change Management in Fisheries Topic Group.

8.1 Introduction

The topic group (TG), *Application of change management in the fishing industry*, was established in 2015 by Steve Eayrs (USA) and Mike Pol (USA) and met annually during the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) meeting until 2017. The goal of the TG was to evaluate the application of organizational change management concepts and models in a fisheries context and to recommend new approaches to overcome resistance and better facilitate change in the commercial fishing industry.

8.1.1 Background

Fishing technologists, conservation engineers, and other researchers have a long history of working to increase fishing efficiency and reduce environmental impacts of commercial fishing gear, often in close collaboration with fishers. However, a common response by fishers, including those involved in the gear development, is to resist changing their fishing gear and practice unless required by regulation. In some instances, they resist change even when it is in their apparent best interests to do so, such as reduction of fuel consumption, reduction in juvenile capture mortality, or protection of marine habitats. This resistance to change has for many years been a source of frustration and confusion to many researchers.

In many businesses, corporations, and industries around the world, efforts to facilitate significant organizational change are increasingly being guided by change management concepts and models. This approach is designed to increase the likelihood of successful and permanent change in staff behaviour, usually in response to a significant threat, crisis, or opportunity, by providing guidance to approach organizational change. In the commercial fishing industry, the application of these concepts and models appears to have been scant, piecemeal, and incomplete, despite their potential to i) increase understanding of, and overcoming, resistance to change by fishers and ii) informing new approaches to achieve successful change outcomes. By reviewing organizational change management literature, and past efforts by members of the TG to facilitate change, it was hoped to identify circumstances, models, techniques, and approaches to guide researchers and successfully realize change in the fishing industry in future.

In the context of this TG, organizational change management can be defined as a deliberate, systematic, and continuous process to renew the capabilities of the fishing industry in anticipation or response to one or more significant events. Fundamentally, organizational change management is about ensuring the survival of an organization, in this instance one or more fishers in a fleet, which is influenced by external variables and pressures that have potential to revolutionize fishing activity.

8.1.2 Terms of Reference

The TG was formed to evaluate the application of organizational change management concepts and models in a fisheries context and recommend new approaches to overcome resistance to change in the fishing industry. The terms of reference (TORs) were:

i) Evaluate the applicability of organizational change management concepts and models in a fisheries context;

ii) Review and evaluate fisheries case studies and initiatives to bring about change;

iii) Explore models of human behaviour that may contribute to resistance to change;

iv) Identify and categorize circumstances and approaches that have led to successful and unsuccessful introduction of change initiatives in fisheries.

8.1.3 Main Outcomes

The main outcomes of the TG can be summarized as follows:

i) The widespread voluntary uptake of successful fishing gear projects is rare, and usually takes place over several years or longer, if at all;

ii) Little evidence was found of the application of formal organizational change management models to facilitate the implementation of new gears or other fishery changes, thus supporting the perception that the application is scant, piecemeal, and incomplete;

iii) Ad hoc, self-developed change management methods have been used to facilitate change, although supporting evidence of their success was limited;

iv) A broad variety of attributes and actions considered important and necessary for change to occur were identified. These were found to be consistent with the Kotter model of organizational change;

v) The deliberations of the TG suggest the Kotter model provides a relevant structure for guiding change in a considered, systematic, and appropriate manner;

vi) The importance of incentives, financial or otherwise, was identified but there was lack of consistency regarding their efficacy. Closing a fishery, regulations, or other drastic threats or inducements can be a strong motivation for uptake, but concern was raised that this type of incentive can result in unenthusiastic and superficial embrace of the change;

vii) No individual reported the application of organizational change management concepts and models was irrelevant in a fisheries context; we therefore assume that organizational change management is a relevant and applicable approach to overcome resistance and facilitate change in the commercial fishing industry;

viii) There was a growing realization that providing quantitative evidence of a need to change was inadequate and that a focus on fear and other emotions that affect decision-making requires greater consideration.

8.1.4 Recommendations

The main recommendations of the TG can be summarized as follows:

i) Fishing technologists and conservation engineers require training in the application of change management theory and principles;

ii) Fishing technologists and conservation engineers require greater understanding of the importance of human behaviour and emotion in decision-making;

iii) Greater efforts are required to link fishing technologists and conservation engineers with individuals trained in human behavior, including the ICES Strategic Initiative on the Human Dimension (SIHD);

iv) Consideration should be given to hosting a related session at the ICES Annual Science Conference, bringing together the TG, SIHD, and others with a shared interested in the topic.

8.2 Participants and Meeting Summaries

The TG met in Lisbon, Portugal (2015); Mérida, Mexico (2016); and Nelson, New Zealand (2017). A total of thirty-eight individuals participated in the TG meetings, representing sixteen countries (Table 8.2.1). Each year, the majority of participants were new to the group; only the conveners participated every year, in part because meeting locations outside the ICES region hampered the ability of individuals to attend.

The TG also worked intersessionally, with some members participating in an online survey on change management, and others reviewing past experiences with the fishing industry in preparation of TG meetings.

Prior to the meeting in Lisbon, individuals in the WGFTFB were contacted by Eayrs and Pol with a request to complete an online survey about change and their perceptions and experiences facilitating change in the fishing industry. The idea of a survey had not previously been considered as a tool relevant to the terms of reference; however, it was decided that a survey would provide useful additional relevant information and context for the TG to consider the TORs. Responses were received from a total of 48 individuals with a history of involvement in the WGFTFB.

8.2.1 Lisbon, Portugal (2015)

In this inaugural meeting Eayrs described types of change and presented the Kotter organizational change management model to the TG (this model was first described by Eayrs at the 2014 WGFTFB meeting in New Bedford, USA). The Kotter model (Figure 8.2.1) is an eight-step process that has been used to guide businesses, corporations, and industries around the world through the process of introducing and cementing revolutionary (i.e. significant) change in a systematic, considered, and preemptive manner. The TG also heard presentations from several participants on change initiatives, including personal case studies and experiences facilitating change in fisheries. A general discussion followed of lessons learned, including the roles of incentives, enforced change through regulation, and the challenges of building trust and fear.

Despite long experience working with the fishing industry in varying capacities (it was estimated that participants in this TG had more than 200 years' cumulative experience working with the fishing industry), TG participants expressed frustration with understanding how change occurs or can be brought about. They almost universally were able to cite experiences where fishers had resisted change in their fishery, either voluntary or mandatory change. A final discussion attempted to categorize the experiences of the group, and an action plan was developed for the intersession, including making attempts to recruit social scientists and other WGFTFB members for involvement in the next meeting.

Table 8.2.1: List of participants (alphabetical after multiyear participant names) and year(s) of participation

Name		Institution	Country	Attendance (yrs)		
Steve	Eayrs	Gulf of Maine Research Institute	USA	2015	2016	2017
Michael	Pol	Massachusetts Division of Marine Fisheries	USA	2015	2016	2017
Ulrik Jes	Hansen	Catch-Fish	Denmark	2015	2016	
Arne	Kinds	ILVO	Belgium	2015	2016	
Pingguo	He	SMAST, University of Massachusetts-Dartmouth	USA	2015	2016	
Daniel	Aguilar	INAPESCA	Mexico	2015		
Crispin	Ashby	Fisheries Research and Development Corp.	Australia			2017
Suzy	Black	Plant & Food Research	New Zealand			2017
Simon	Boag	Atlantis Fisheries Consulting Group	Australia			2017
Aida	Campos	IPMA	Portugal	2015		
Leela	Edwin*	Central Institute of Fisheries Technology	India	2015		
Arill	Engås	Institute of Marine Fisheries	Norway		2016	
Jordan	Feekings	DTU-Aqua	Denmark			2017
Tereza	Fonseca	Southwest Western Atlantic Advisory Council	Portugal	2015		
Rikke	Frandsen	DTU-Aqua	Denmark	2015		
Carwyn	Hammond	NOAA/AFSC	USA		2016	
Troy	Hartley*	Virginia Institute of Marine Science	USA			2017
Lekelia	Jenkins	Arizona State University	USA			2017
Emma	Jones	NIWA	New Zealand			2017
Junita	Karlsen	DTU-Aqua	Denmark			2017
Peter	Ljundberg	SLU	Sweden		2016	
Damian	Moran	Plant & Food Research	New Zealand			2017
Thomas	Moth-Poulsen	FAO	Turkey	2015		
Aileen	Nimick	Alaska Pacific University	USA		2016	
Thomas	Noack	DTU-Aqua	Denmark	2015		
Emilio	Notti	CNR-ISMAR	Italy		2016	
Barry	O'Neill	Marine Scotland	Scotland		2016	
Phil	Ravanello	Australian Fisheries Management Agency	Australia			2017
Ismet	Saygu	Cukurova University	Turkey	2015		
Suresh A.	Sethi	Cornell University and Alaska Pacific University	USA		2016	
Ben	Sodenkamp	Arizona State University	USA			2017
Daniel	Stepputtis	Thunen Institute of Baltic Sea Fisheries	Germany		2016	
Petri	Suuronen	FAO	Italy	2015		
François	Théret	SCAPECHE	France		2016	
John Willy	Valdemarsen	IMR	Norway	2015		
Benoit	Vincent	IFREMER	France		2016	
Liuxiong	Xu	Shanghai Ocean Univ.	China		2016	
Susie	Zagorski	Alaska Pacific University	USA		2016	

*by email

8.2.2 Mérida, Mexico (2016)

This TG meeting was supported by a preceding plenary session with five talks relevant to the TG as part of the joint FAO-ICES Symposium, including one by Eayrs that presented the results from the intersessional survey.

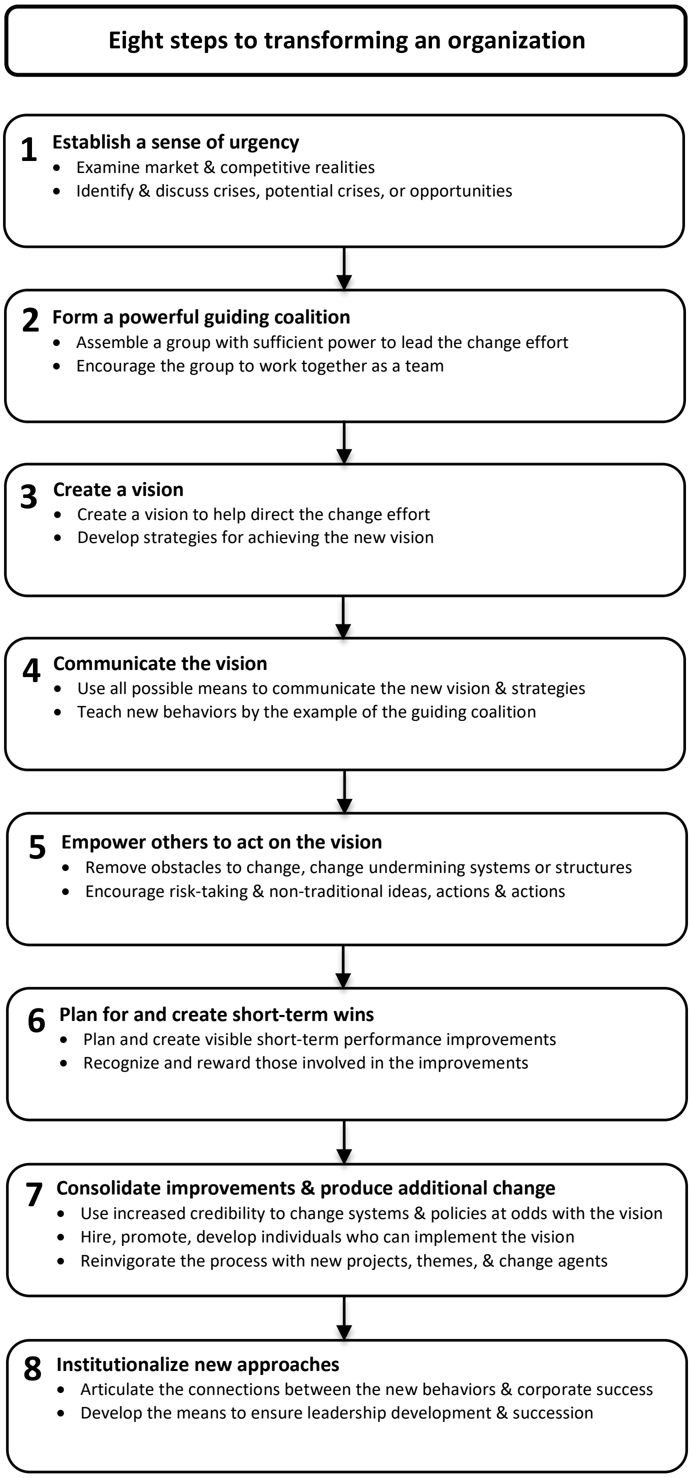


Figure 8.2.1. Kotter's eight-step change management model. (Adapted from Kotter, 1996.)

During the TG meeting, progress against the terms of reference was reviewed, followed by presentations by individuals that applied the Kotter model to personal case histories describing efforts to facilitate change in the fishing industry. Overall it was found the case histories inadvertently contained some features or attributes of the

Kotter model, but no studies were found that utilized the entire model. Furthermore, no one particular step of the model was deemed to determine success or failure of a change initiative – all were deemed important and necessary – and no one step was deemed more important than others. It was particularly notable that a key step lacking in most case histories was a clear vision articulated to all fishers and participating stakeholders.

Following these presentations, the group was split in two and each given a case study with a goal of applying the Kotter model. Following presentation of those results, a wrap-up was held with next steps developed. Unfortunately, we were unsuccessful identifying and attracting social scientists with an interest in change in fisheries to this meeting, but pledged to seek suitable individuals to the next meeting.

8.2.3 Nelson, New Zealand (2017)

Prior to this meeting two social scientists (Jenkins and Hartley) were recruited to bring their insight and perspectives on change management in fisheries to the meeting and facilitate discussion related to the term of reference: identification and categorization of circumstances and approaches that led to successful and unsuccessful change in fisheries. Unfortunately, Hartley's participation was curtailed just prior to the meeting due to last-minute work commitments.

Once again, relevant talks were presented in plenary prior to the TG meeting, principally from Australia and New Zealand. In the TG session, a brief recapitulation of progress was made, and then Jenkins led the TG in a workshop session to draw out the experiences of the group with successful change management, using a facilitated technique. At the conclusion of the meeting, Eayrs and Pol compiled meeting notes and commenced the final report.

8.3 Results and Discussion

The findings of the TG are described in the context of the four terms of reference. Additional salient findings from the intersessional online survey and from relevant presentations during plenary in the Working Group meetings in Lisbon, Mérida, and Nelson are also described.

8.3.1 Evaluate the applicability of organizational change management concepts and models in a fisheries context

The objective of this term of reference was to learn how TG members facilitate change in the fishing industry and the extent to which they use organizational change management concepts and models.

8.3.1.1 Online survey

Evidence from the online survey and TG participants provided few examples of deliberate application of organizational change management concepts and models. Of the 48 respondents who completed the survey, only 13% indicated they use a formal or recognized model of organizational change, 50% indicated they did not use a formal or recognized model, and 31% indicated it was not part of their job. It was not possible to determine how many respondents indicated they did not use a formal or recognized model because they were unfamiliar with models of organizational change and therefore unaware they may be applying concepts or models in part or in full. Individuals that responded in the affirmative were requested to provide further details of the model they used. Only five individuals responded to this request; however, their responses provide useful insight:

- *"I use several models of behaviour change. This is based on theories I have developed while working in the Peace Corps and working as an extension agent for Sea Grant and most recently in the international work I have been involved in."*
- *"Integrated Sustainability Assessment (ISA)"*
- *"not so much a formal model, but a flexible approach has been agreed with the fishing industry. It has been put in place really so we can prioritize projects if insufficient resources are available. Briefly, fisher/netmakers are encouraged to develop and trial new gears themselves. If they are happy with them then observers, from the industry federation will carry out a basic assessment (usually in relation to catching performance). Then depending on the level of evidence required (e.g. to convince the EU commission) full-scale scientific trials may be carried out by Marine Scotland Science. Furthermore, MSS are available at all stages of the process to advise."*
- *"EAF (Ecosystem Approach to Fisheries) process"*
- *"voluntary guidelines - NPOA's. IPOA's - RFO resolutions, awareness raising programs, stakeholder meetings, workshops"*

In part due to the small sample size, a high degree of variability was seen between responses, including the application of both formal and informal approaches to facilitating change. This result, coupled with the large number of respondents not using a formal approach, implies no one single approach to change management has been identified or was being used by individuals in the WGFTFB to facilitate change in the fishing industry.

Supporting this thesis, 33% of individuals indicated they developed their strategy to facilitate change by trial and error, while only 21% of individuals indicated their strategy was a blend of formal training and trial and error. These results indicate interest in bringing about change, but are deficit in method or knowledge of how to do so.

8.3.1.2 Kotter organizational change model

During the period of the TG, the Kotter organizational change model (Figure 1) was discussed and evaluated for suitability in a fisheries context. The model was described in detail and suggested as a cost-effective way to approach revolutionary change and overcome resistance by fishers. It was also presented as a strawman, given no previous evidence of using this model in a fisheries context had been found, and because it was unclear if the model could withstand review by the TG.

The Kotter model was explored in greater detail in the second TG meeting, and several presenters provided examples of efforts to facilitate change in the context of this model. This effort provided individuals an opportunity to explore the utility of the model, to seek insights that might explain why or how an initiative to facilitate change did not fully achieve target outcomes, and to guide facilitation of future change initiatives. No examples were provided of the model being used proactively to guide change; all examples involved retrospective fitting of the model to describe a past change initiative, although some participants indicated potential future use of the model. In one case, the concept of preparedness for change was presented as a precondition for change under the Kotter model.

During this meeting the TG was split into two groups. Each group explored a separate topic, one an industry initiative to reduce loss of plastic threads that protect trawl codends from abrasion into the environment, and the other to explore the issue of a fleet of ageing fishers. Each group was required to explore their issue and provide a plan to facilitate change based on the Kotter model. Both groups found the Kotter model useful to identify shortcomings in the industry initiative and address the issue of an ageing fleet of fishers.

8.3.1.3 Other organizational change management concepts and models

During the first TG meeting Eayrs presented several change management concepts, including The Paradox of Fishermen, the Elephant and the Rider metaphor of human behaviour, and Prospect Theory (see Section 3.3 for description). Examples were provided in a fisheries context. At the second meeting, a model of strategic readiness to change was presented (see Section 3.2.3).

No other formal organizational change management models were identified by the TG. Many models have been described in the literature; however, their lack of identification by the TG suggests individuals were unaware of their existence.

Soon after the meeting in Nelson, an opportunity presented for Eayrs to meet with the only individual from the online survey that had been using models of human behaviour to help facilitate change in fisheries. This individual was using the ADKAR model – awareness, desire, knowledge, ability, and reinforcement – which focuses on the necessary attributes of a change recipient for change to be successful (Figure 8.3.1). The first step is awareness of the need to change, based on effective and persistent communication. The next is the desire to engage and participate in the change initiative and strive toward a successful outcome, followed by knowledge regarding the necessary steps to achieve the desired outcome and how to accomplish each step.

Figure 8.3.1: The ADKAR model (adapted from https://www.prosci.com/adkar/adkar-model).

Next is an ability to implement change and realize the desired outcome or level of performance, and finally, reinforcement is necessary to ensure the change persists (sticks) and the desired outcome is maintained.

8.3.2 Review and evaluate fisheries case studies and initiatives to bring about change

During the three-year period of the TG, numerous fisheries case studies and initiatives to bring about change were described, both during plenary and the TG, either in formal presentations or informal oral reports and anecdotes. This review and evaluation was also supported by responses by the WGFTFB to the online survey.

8.3.2.1 Online survey

Respondents were asked to indicate from a list of options the fishery organizations and groups that are fully or partially responsible for *facilitating the adoption of new/modified fishing gear or practice, either voluntarily or in response to regulation*. The majority of respondents (88%) indicated that government bodies/agencies were fully or partially responsible for this facilitation, while 83% of respondents suggested fishing industry organizations and 82% suggested fishers themselves. Just fewer than 80% of respondents thought it a role of research organizations. Only 40% of respondents thought it a role of non-governmental organizations and 27% thought it a role of inter-governmental organizations. These proportions remained relatively unchanged when the same respondents were asked which fishery organizations and groups were responsible for *facilitating the adoption and use of fishing gear to reduce environmental impacts and increase efficiency and profitability*.

Respondents were asked to indicate from a list of options the various tools they use to facilitate change. Almost 90% of respondents indicated they use face to face communication while just over 80% use industry meetings and workshops. The remainder of options were ranked substantially lower, with at sea training used by 52% of respondents, technology transfer by 50% of respondents, project reports by 48% of respondents, and incentives including gear loans and fishing opportunities by only 46% of respondents.

In response to the question regarding why they thought fishers were generally resistant to significant change, respondents most commonly selected (by decreasing order of importance): *Concerns that change will be costly or painful*; *Perceived lack of incentives to offset catch loss*; *Perceived lack of control over their fishing operation or business*; *Uncertainty about the future and how they might be affected by change*; and *Perceived lack of opportunity, benefit, or reward from change*. The least commonly selected responses were *Concerns by individuals that they will appear incompetent in the face of change* and *Insufficient time to become adjusted to the idea of change*.

8.3.2.2 The VALDUVIS model

The VALDUVIS model (Figure 8.3.2), presented by Kinds, was developed in Belgium as a way to assess, visualize, and monitor the sustainability of individual commercial fishing fishers/vessels on a trip by trip

basis. It also serves to develop multifaceted measures of sustainability, in alignment with existing certification schemes, that suit the requirements of all stakeholders, including fishers, researchers, managers, policy-makers, and seafood certification bodies. It includes the provision of fisheries logbook data and other information to automatically generate sustainability scores, which are available to other stakeholders soon after landing the catch, and it includes measurement against a suite of socio-economic indicators. An incentive for the involvement of fishers in this initiative was the potential for improved access to seafood markets.

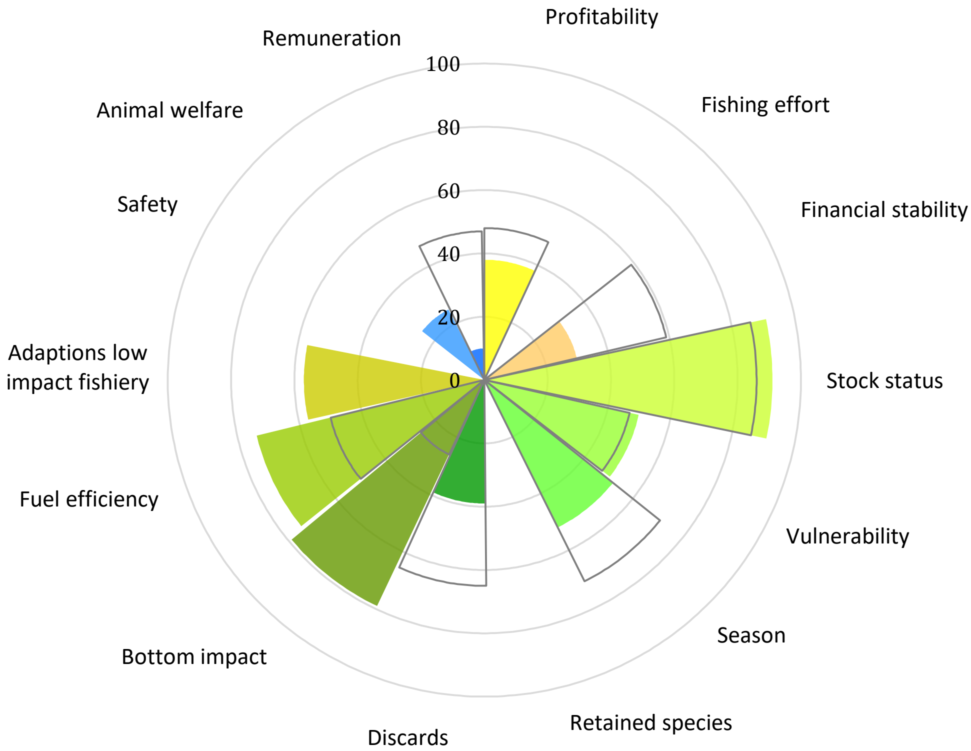


Figure 8.3.2. The VALDUVIS model. For each category a score is provided against a reference point (solid line).

8.3.2.3 The strategic readiness model

This model was presented by He to analyse the seemingly rapid adoption of the Nordmøre grid in the Gulf of Maine shrimp fishery. This model can be used to evaluate a change initiative from multiple angles related to political, economic, social, technical, legal, and environmental perspectives, either retrospectively or proactively. It emphasizes the preconditions necessary to permit change to occur. At the time the Nordmøre grid was introduced into the Gulf of Maine shrimp fishery, fishers were under political pressure in the form of threats to close the fishery due to incidental catch and discard of groundfish, including juveniles. The impact of these threats was to place shrimp fishers under significant economic uncertainty, because they were unsure of the future of fishing activity for shrimp. Socially the fishery was considered to be 'dirty' by the public and some other stakeholders due to discards of groundfish, which contributed significantly to a sense of pressure felt by fishers. Technologically the grid was considered suitable for the fishery, having been under development for at least a decade in shrimp fisheries in Europe using similar trawl gear. Overfishing of groundfish had resulted in NGOs suing management authorities over their lack of success preventing overfishing, and environmentally, the collapse of the Newfoundland cod fisheries was still reverberating through New England, especially as many shrimp fishers also fished for groundfish. Subsequently, fishers were under tremendous pressure to change fishing practice, and over a period of less than one year, fishers adopted the grid and it became a mandatory requirement in the fishery.

8.3.3 Explore models of human behaviour that may contribute to resistance to change

This term of reference was the most challenging primarily because TG participants had limited prior knowledge of human psychology and sociology. Several models of human behaviour were presented by Eayrs including The Paradox of Fishermen, the Elephant and the Rider analogy, and Prospect Theory. These models were discussed briefly, and few participants were aware of these models or provided comment on their application in a fisheries context.

The Paradox of Fishermen is a comment on the apparent resistance or reluctance of fishers to change. This resistance is paradoxical because fishers operate daily in an environment that is ever-changing and often unpredictable, and while they readily respond and adapt to these day-to-day changes, they tend to resist other, less frequent, significant change, including changes to fishing gear. This contradiction in behaviour is called The Paradox of Fishermen. The Elephant and the Rider analogy describes how, despite our perception of ourselves as motivated by logic, human behaviour is primarily led by emotion (the elephant) rather than by rational (the rider) decision-making. The relative size of the elephant is indicative of the challenge presented to the rider in reining in the elephant, particularly one moving quickly. The elephant can also be stubborn and resist movement, despite the best efforts of the rider. This analogy illustrates the potential limits of logic and evidence to alter behaviour. Prospect Theory attempts to describe the risk-averse behaviour of humans. It describes how humans 'value' success and failure, and that we typically value failure more highly. For example, the value placed on finding $100 is less than the value placed on losing the same amount, and while the value placed on finding (or losing) a $100 a second time is less than the first (theoretically reaching an asymptote if repeated enough times), the value of the second loss remains greater than the gain. Fundamentally, prospect theory suggests that resistance to change may be influenced by fear of failure, and that we are naturally geared toward its avoidance.

The challenge of building trust with fishers and the relative ease that trust can be lost was discussed frequently, although there was only very general discussion about ways to build trust (see 3.4.1.1 for additional discussion). It was also noted that working with fishers in gear development is a preferred approach but can be risky, as a bad initial experience with a new gear can dissuade fishers from further development or engagement, to the extent that consideration of refinement or development is not an option. Building trust was also a primary factor in facilitating change that arose during the final meeting's facilitated discussion.

An important discussion during the Merida meeting revolved around the perception that trawl fishers in the New England groundfish fishery are more reluctant to change compared to trawl fishers in the Alaskan pollock fishery. The New England fishery is characterized by small, traditional trawlers owned and operated by individual fishers, while the Alaskan fishery is characterized by factory trawlers owned by large corporations. It was suggested that ownership by corporations encourages a long-term view and investment, and that fishers are professionalized and work more closely together due in part because personal relationships seemingly matter more in Alaska, with greater trust between fishers, and between fishers and fishing technologists, and netmakers and others supporting the development and testing of new fishing gear. Finally, it was posited that the relative health of stocks in each fishery, and the relative profitability of fishers in Alaska, are significant factors that contribute to a greater level of cooperation and change readiness. Further evaluation of these differences, or identification of other important differences, was not possible by individuals reporting on each fishery due to limited knowledge and understanding of drivers behind human behaviour and decision-making.

The effectiveness of financial incentives was a common discussion topic at each meeting. In Australia's Northern Prawn Fishery, relatively few owner-operators participated in a recent initiative to develop bycatch reduction devices for finfish, despite an incentive up to AU $20,000 for the development of a new device that achieved bycatch reduction targets. In contrast, individuals employed by supportive fishing enterprises dominated these efforts and were generally more active in considering the design of new device, although the significance of their employment status and the extent that it mattered are unknown. In New England, several incentives, financial and otherwise, had been attempted with poor results, including the provision to one fisher of a fuel flowmeter free of charge, including installation at a convenient time and place, but who returned it three years later unused in original packaging. It also included a poor response to a scheme to encourage fishers to purchase semi-pelagic trawl doors and a fuel flowmeter, which included a rebate of US $2,500 following their purchase, with the option of a low interest loan to purchase this gear and repayments capped at 10% of their annual fuel costs (an amount equivalent to the fuel saved using the doors), despite evidence of payback periods as short as six months.

The challenges of facilitating change with Danish fishers despite extensive industry collaboration and use of financial incentives was discussed (in Nelson). This was blamed in part by use of incorrect incentives, sometimes producing unanticipated outcomes, inadequate data collection to encourage adoption by fishers, and a history of frustration for fishers due to lack of follow up and assistance by researchers and fishers once project funding has expired. To overcome this issue a fast-track system is being applied, whereby ideas for gear improvement by fishers are quickly evaluated by a panel of experts. Suitable ideas are then tested by fishers under normal commercial conditions, results are evaluated, and if promising they are followed by controlled scientific testing. A requirement for extensive promotion and outreach was also flagged as essential to facilitate change in the fishing industry.

8.3.4 Identify and categorize circumstances and approaches that led to both the successful and unsuccessful introduction of change initiatives in fisheries

The accomplishment of this term of reference was achieved primarily during the TG meeting in Nelson, with support of the online survey and participant presentations and discussions during plenary and TG meetings in Lisbon and Mérida.

8.3.4.1 Facilitated discussion

During this meeting the conveners were joined by Jenkins, with participants from Denmark, Australia, and New Zealand. Initially relevant comments, insights, and personal experiences were provided by participants and discussed among the group.

Jenkins then led a group exercise with the objective of identifying elements of successful and unsuccessful change initiatives. Each participant was asked to identify individual elements of success or lack of success, write them down on sticky notes, and then place them on a wall grouped by success or lack of success. As this activity unfolded it became apparent that elements of unsuccessful change initiatives were simply opposites of successful initiatives, and a decision was made to spend remaining time focusing only on the latter. Two participants were randomly selected and given a few minutes to categorize all successful change elements by common characteristic or feature. Another two participants were then selected and given the same period to refine the categorization of elements. This process continued until all participants had an opportunity to contribute to the categorization. Thereafter the entire group reviewed the categories.

During this review the entire group agreed that all identified elements could be sorted into broader categories labelled *Facilitator Qualities*, *Project Execution*, *Ownership and Motivation*, *Timing*, and *Communication*. Each category was discussed in some detail, although time permitted only a high-level consideration of each element during the meeting.

8.3.4.1.1 Facilitator qualities

The group agreed the qualities of a facilitator played an important role in successful change initiatives and included respect, care, and concern for change recipients, as well as persistence, active participation, experience, and credibility. Achieving respect and demonstrating care and concern for fishers and their circumstances requires the facilitator to have spent time on the water getting to know fishers, their fishery, and related issues and concerns. This interaction fosters closer engagement with fishers and helps build empathy and trust. Persistence was considered important, particularly repetition of information to fishers to drive the message home, including their need to change and respond. Active participation by the change facilitator demonstrates a high level of commitment to achievement of a successful outcome, and helps develop the remaining aforementioned qualities. The facilitator needs to have substantial experience in the fishery with good knowledge and understanding of fishers, and this is achieved only after a long period of time engagement in the fishery. Finally, the facilitator needs to be considered credible, which is supported by a perception of honesty and demonstration of the remaining facilitator qualities.

8.3.4.1.2 Project execution

The execution of a successful change initiative requires considerable preparation, accomplishment of appropriate tests and trials, measurement of effects, and follow-up. Preparation includes clear identification of the roles of participating individuals as well as information requirements and flows, as well as alignment of expectations by all participants. This preparation is followed by tests and trials, usually by placing scientists and data collectors on commercial fishing vessels, and includes providing suitable incentives to engage fishers. Measuring the effects of the project follows, using appropriate metrics and clearly identified measuring practices and protocols. Finally, follow-up is important, particularly to seek validation from fishers or others that the initiative is having the desired impact, to collect feedback on performance and improvements, maintaining a channel for communication and maintaining interest, and planning for further implementation if necessary or desirable.

8.3.4.1.3 Ownership and Motivation

This category was deemed to require ownership of the issue and solution by change facilitators, a high degree of leadership and/or an effective, highly personable spokesperson, and an ability to identify opportunities and overcome threats. This can be achieved through education/empowerment of change facilitators and recipients. Social license (the recognition that people must generally accept an activity such as commercial fishing for it to be tolerated and allowed to continue, despite whether the activity is legal or not), a strategic, proactive business environment on the part of the fishing fleet, and a customer-driven focus from researchers towards fishers were also deemed to be important.

8.3.4.1.4 Timing

Timing of change initiatives was deemed important because of its relationship with planning of related activity, and to the need for a solution. Engaging early with stakeholders is important because it helps them prepare accordingly. Planning needed to be tactical, strategic, and focused on outputs, including results, extension, and adoption of the realized change.

8.3.4.1.5 Communication

Finally, communication was considered essential, and a communication strategy should be developed that includes showcasing progress and success either face to face or via a variety of media such as Facebook, Internet, letters, and reports. The strategy should include a blend of options to raise awareness and facilitate engagement including port visits, sea trials on commercial vessels, feedback loops, and follow-up to enquiries. The language used to present the communications should be plain, easily understood without jargon, appropriate, and empathetic where necessary. Importantly, communication should be persistent because repetition is important to ensure the message sinks in and is understood.

Toward the end of the meeting a framework was proposed that attempted to capture the meaning and intent of each identified element (Figure 8.3.3). Efforts to facilitate change (project execution) were influenced by project timing, which in turn were influenced by facilitator qualities as well as ownership and motivation. Underpinning all elements was the element of communication. This framework was only briefly discussed before the meeting concluded, and while there was no major objection to the framework, it was not considered in depth.

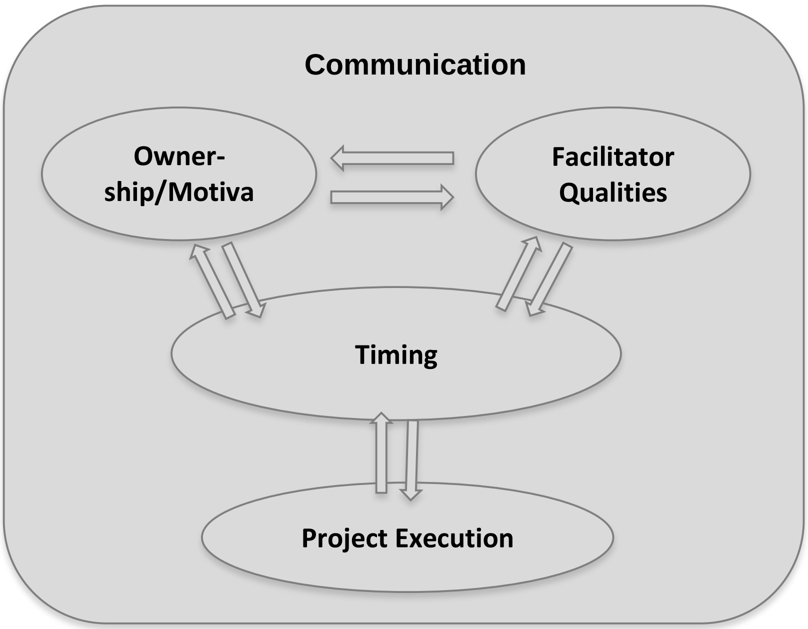


Figure 8.3.3. Proposed framework for facilitating change.

8.3.4.2 Discussions of Incentives

The utility and efficacy of incentives, in particular financial incentives, to encourage change was raised several times during plenary and TG group discussions in Lisbon and Mérida. Some participants felt that appropriate financial incentives were the solution to facilitating change, however, multiple examples were provided whereby direct financial incentives had not produced the desired outcome. Examples were also provided where indirect financial incentives, such as the provision of fishing gear or fuel flowmeters that reduce fuel costs, had not encouraged adoption of new gear despite being provided at no cost or with high subsidy. An example was the low level of interest in using semi-pelagic trawl doors and fuel flowmeters on groundfish trawlers in New England (see section 3.3 for details).

A study was also provided from India where fishers in the 1980s rapidly adopted ring seine fishing gear to capture small pelagic species. Over a period of approximately 10 years many fishers from the state of Kerala adopted this fishing gear, and by the early 2000s several thousand fishers from around the Indian coast had done likewise despite efforts by authorities to curb rapid growth in this fishing method. The size of the ring seine and boat size also increased substantially during this period. No rationale for the pace of adoption or changes in behaviour were provided (the author (Edwin) was unable to attend the meeting but kindly provided her presentation), but it is possible that fishers were incentivized to adopt this gear by a desire to increase profitability in the early years of the fishery, when cpue was relatively high, and later to increase gear and boats size in an effort to offset dwindling cpue.

8.3.4.3 Outreach and extension programs

The efficacy of outreach programs was discussed numerous times during each meeting. Hansen presented a personal retrospective of his efforts as a government scientist and as an independent business to work with fishers over many decades and encourage the adoption of new or modified fishing gear (see Appendix 5). Despite his long experience and use of multiple outreach strategies, including flume tank demonstrations, instructional pamphlets, papers, reports in industry literature, presentations at industry and scientific meetings, workshops, and conferences, and face to face discussions, the adoption of this gear had been modest at best, and in very few instances did fisher voluntarily adopt the gear. Other senior participants recounted similar stories, and even opportunities for fishers to test new gear on their boat at a convenient time under the tutelage of an expert rarely realized favourable outcomes. Generally, despite long experience, participants could not identify approaches that led to successful or unsuccessful introduction of change initiatives in fisheries.

8.4 Conclusions

Based on the outcomes of the TG, the following observations and conclusions can be made:

- We found no examples of research by conservation engineers or others to develop new or modified fishing gear that enjoyed widespread voluntary adoption by a group of fishers. Despite efforts and desire to create change over many years' experience by participants in the TG, and the application of multiple strategies to encourage change, the rate of change was always slow and inconsistent between fishers or totally absent. Some examples of gear adoption were identified by the TG but were almost always the result of impending or imposed regulation, irrespective of the new gear providing economic or other benefits to fishers. The relatively low rate of voluntary adoption was widespread across ICES Member Countries, and not confined to any particular country.
- No examples were found of organizational change management models being used by the TG to facilitate implementation of new gears or other fishery changes. Ad hoc or self-developed methods have been used to realize limited success, which inadvertently featured limited components or fea-

tures of the Kotter model. Only one individual from the WGFTFB (participating via the online survey only) indicated the use of change management models, using a self-developed blended approach based on the ADKAR model. There is a high degree of similarity between the two models; both encourage a systematic and stepwise approach to facilitating change (although both recognize that some steps can be addressed simultaneously). The results of the online survey suggest the application of any type of formal training to facilitate change is rare between individuals, and seemingly highly variable in type and scope.

- A broad variety of attributes and actions considered important and necessary for change to occur were identified, primarily communication, vision, and facilitator attributes. These factors were found to be consistent with the Kotter model of organizational change, although it was not possible to determine their relative importance. In particular, it was recognized that the frequency and intensity of communication to change recipients needed to be much greater than typically conducted or funded. The importance of a clear vision statement, including widespread and repetitive articulation of the statement, was found to be key, yet was often lacking or unclear in past change initiatives. The duration of funded projects was often considered too short in contrast to the time necessary to facilitate widespread communication of project results and the adoption of new gear by fishers.
- The deliberations of the TG suggest that the Kotter model provides a relevant structure for guiding change in a systematic and considered manner in commercial fisheries. Retrospective evaluation of past change initiatives found this model highly relevant and capable of identifying where or why these initiatives did not achieve optimal outcomes. No examples were found of this model being used proactively.
- The importance of incentives, financial or otherwise, was identified by the TG but there was lack of consistency regarding their efficacy. Subsequently the TG developed little understanding of the types of incentives necessary, either singly or blended, and the timing and magnitude necessary to motivate change in the fishing industry.
- The wide geographical spread of TG meetings was problematic and resulted in only the conveners attending all three meetings. While the location of the meetings permitted broader collection of information related to the TG, a lack of continuity hampered an ability to delve deeper into the topic of change in fisheries. The final meeting location also hampered the inability of Hartley to attend the final meeting and provide vital insight into human behaviour and decision-making.
- While the application of change management models provides a useful framework and guidance to facilitate change, there was a growing realization by Eayrs and Pol that human behaviour and emotion plays a significant role in influencing the participation of fishers in change initiatives. In particular, it appears that fear is a dominant emotion influencing the success of these initiatives. This is a significant realization given that fishing technologists and conservation engineers rely heavily on quantitative evidence to encourage fishers to change. Typically, their approach is to use facts to demonstrate to fishers that a need to change exists, with little time spent considering how fear or other emotions may affect fishers and influence their decision-making. Subsequently, a lack of focus on the emotions of

fishers may hold the key to overturning the low success rate of change initiatives.

8.5 Recommendations

Based on these conclusions, we recommend the following next steps to improve uptake of new fishing gears and practices in commercial fisheries:

- Fishing technologists and conservation engineers seeking change in fisher behaviour require training in the application of change management theory and principles. This includes the application (and limitation) of change management models such as the Kotter model.
- Fishing technologists and conservation engineers require greater understanding of the importance of human behaviour and emotion in decision-making, including tools to recognize emotions at play and how to guide these emotions to achieve successful outcomes.
- Efforts to form a closer relationship between WGFTFB with the ICES Strategic Initiative on the Human Dimension (SIHD) should be considered. Initial efforts via e-mail have already been made to connect with this group, although additional efforts are required to i) inform this group of TG outcomes and ii) explore future collaborative needs and opportunities.
- Eayrs, Pol, Jenkins, and Hartley should agree to continue their investigation of change management and in particular explore human dimensions to change in fisheries, as the adoption of necessary changes cross cuts many disciplines beyond the remit of WGFTFB.
- The potential of a related session at the ICES Annual Science Conference should be considered to share knowledge and build relationships between the TG, SIHD, and others with an interest in the topic.

8.6 Appendices

8.6.1 Agenda – Lisbon, Portugal (2015)

Time	Activity	Chair
0840	Introduction – Agenda, purpose, scope, and objectives of TG; Housekeeping (Eayrs)	Eayrs
0900 - 0915	Introduction of participants and interest in TG (All participants)	Pol
0915 - 1000	Setting the scene: Types of change; Factors that affect change in the fishing industry, incl. prospect theory, introduction to the Kotter model (Eayrs)	Pol
1030-1050	Coffee	
1050 - 1110	Tracking the Evolution of Ring seine Fishing System of India and Interventions to ensure sustainability of the fishery (Edwin, L. *et al.*)	Pol
1110 – 1130	VALDUVIS: integrated sustainability assessment by a cost-effective use of existing data and science-based indicators, affordable to any scale of fishery (Kinds, Arne. *et al.*)	Pol
1150 - 1230	Case studies and initiatives to bring about change – oral reports (All participants)	Pol
1230-1330	Lunch	

1330 - 1400	Case studies and initiatives to bring about change – oral reports (All participants)	Pol
1400 - 1500	Lessons learned from case studies/general discussion The role of incentives in achieving outcomes The influence of impending legislation/regulation on the response and reaction of fisher How trust-building was an integral component of the initiative (or not) How fear of financial/other loss influenced their reaction and response.	Pol
1500- 1520	Coffee	
1520	Categorization exercise: Are their core characteristics of a fishery or fisher that increase resistance to change? What are essential components of a change initiative? What can we learn from the questionnaire? Are industrial fleets more accommodating of change compared to owner/operator or subsistence fleets? Are we in agreement with change terminology? How relevant is the Kotter model in a fishery context? Other models? Do we need external expert advice?	Eayrs
1630	Wrap up discussion, next steps and future activity, and concluding remarks.	Eayrs/Pol
1700	End	

8.6.2 Agenda – Mérida, Mexico (2016)

Time	Activity
0900 – 0915	Introduction – Agenda, purpose, scope, and objectives of TG; Housekeeping (Eayrs)
0915 – 0930	Introduction of participants
0930 – 1040	Summary of 2015 meeting (Eayrs) What role can organizational change management play in encouraging change in the New England groundfishery? (Eayrs) Technological change and the Kotter model: A case study with the raised footrope trawl (Pol) Reconversion of a trawler to a longliner to target black scabbard and hake (Theret)
1040 – 1100	Coffee
1120 – 1230	Implementing change in the North Pacific bottom-trawl groundfish fishery: sweep modifications success (Sethi/Hammond) Successful Nordmore grid implementation in the Gulf of Maine shrimp fishery: external environmental analysis (He) Managing change in the Belgian fishery (Kinds)
1230 – 1400	Lunch
1400 – 1530	Technical measures in the Baltic Sea – an alternative to over-regulation and the brace-and-belt approach (Stepputtis) Case studies (2 groups)

	Graying fisher Dolly ropes
1530 – 1600	Coffee
1600 – 1715	Case study presentations Group 2: Graying Fisher presentation and discussion (Pol) Group 1: Dolly Ropes presentation and discussion (Zagorski) Wrap up discussion, next steps and future activity, and concluding remarks.

8.6.3 Agenda – Nelson, New Zealand (2017)

Time	Activity
1100 – 1210	Introductions/presentations/discussion (Pol)
1210 – 1340	Lunch break
1340 – 1500	Categorization exercise (Jenkins)
1500 – 1530	Tea break
1530 - 1700	Exercise continued; wrap up discussions; conclusions; next steps (Eayrs)

8.6.4 Online survey results

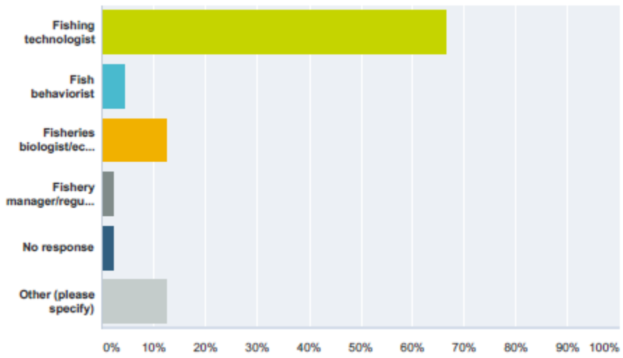
Q1 Please insert your name, company or affiliation, and contact details. These details are only required should I need to contact you or to share final summary data. You may choose not to provide these details.

Answered: 44 Skipped: 4

Answer Choices	Responses	
Name	100.00%	44
Company or Affiliation	95.45%	42
Address	77.27%	34
Address 2	4.55%	2
City/Town	86.36%	38
State/Province	38.64%	17
ZIP/Postal Code	75.00%	33
Country	88.64%	39
Email Address	90.91%	40
Phone Number	77.27%	34

Q2 Please select from the list below your current primary position of employment:

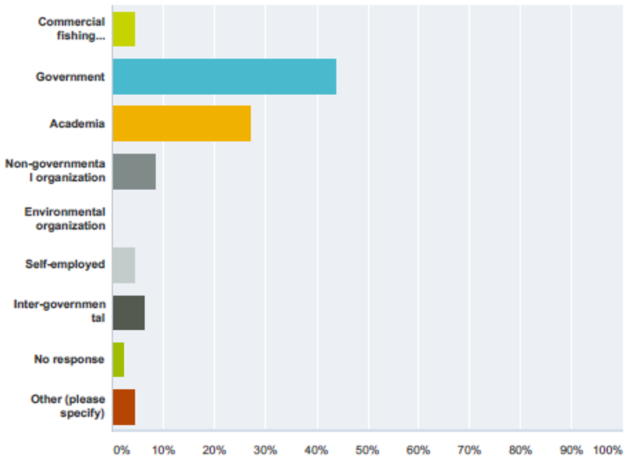
Answered: 48 Skipped: 0



Answer Choices	Responses	
Fishing technologist	66.67%	32
Fish behaviorist	4.17%	2
Fisheries biologist/ecologist	12.50%	6
Fishery manager/regulator	2.08%	1
No response	2.08%	1
Other (please specify)	12.50%	6
Total		48

Q3 Please select from the list below the answer that most closely describes your institution/employer:

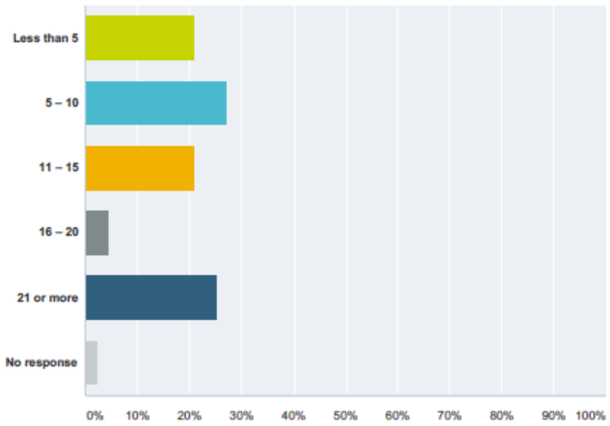
Answered: 48 Skipped: 0



Answer Choices	Responses	
Commercial fishing company/business	4.17%	2
Government	43.75%	21
Academia	27.08%	13
Non-governmental organization	8.33%	4
Environmental organization	0.00%	0
Self-employed	4.17%	2
Inter-governmental	6.25%	3
No response	2.08%	1
Other (please specify)	4.17%	2
Total		48

Q4 How many years have you been employed in your current primary position?

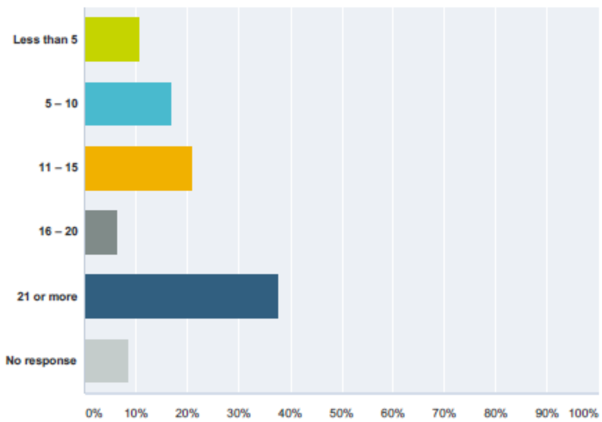
Answered: 48 Skipped: 0



Answer Choices	Responses	
Less than 5	20.83%	10
5 – 10	27.08%	13
11 – 15	20.83%	10
16 – 20	4.17%	2
21 or more	25.00%	12
No response	2.08%	1
Total		48

Q5 How many years have you been employed in any capacity related to the commercial fishing industry (include years indicated in previous question)?

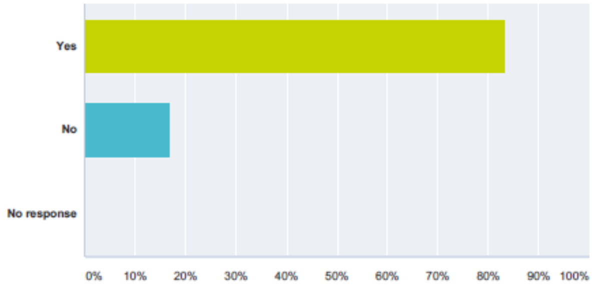
Answered: 48 Skipped: 0



Answer Choices	Responses	
Less than 5	10.42%	5
5 – 10	16.67%	8
11 – 15	20.83%	10
16 – 20	6.25%	3
21 or more	37.50%	18
No response	8.33%	4
Total		48

Q6 Is one of your roles/duties in your current position to work closely with commercial fishers to facilitate/implement their adoption and use of new/modified fishing gear or practice due to regulatory or mandatory change in the fishery?

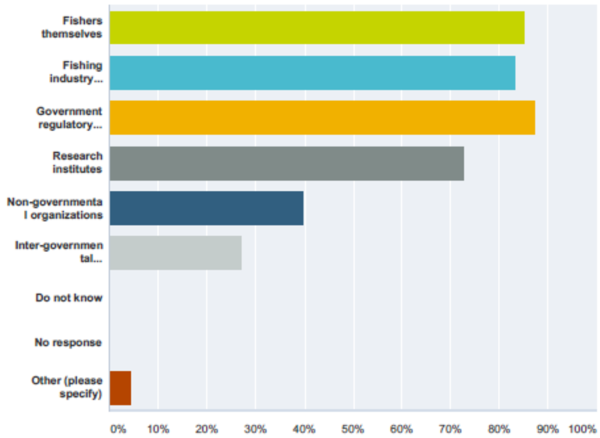
Answered: 48 Skipped: 0



Answer Choices	Responses	
Yes	83.33%	40
No	16.67%	8
No response	0.00%	0
Total		48

Q7 Who do you think is responsible for working with commercial fishers to facilitate/implement their adoption and use of new/modified fishing gear or practice due to regulatory or mandatory change in the fishery? Please indicate all responses that apply.

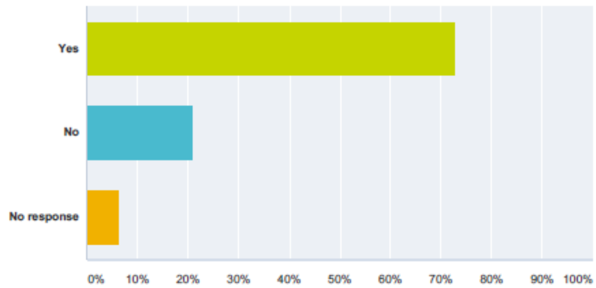
Answered: 48 Skipped: 0



Answer Choices	Responses	
Fishers themselves	85.42%	41
Fishing industry organizations/cooperatives	83.33%	40
Government regulatory bodies/agencies	87.50%	42
Research institutes	72.92%	35
Non-governmental organizations	39.58%	19
Inter-governmental organizations	27.08%	13
Do not know	0.00%	0
No response	0.00%	0
Other (please specify)	4.17%	2

Q8 Is it one of the roles/duties in your current position to facilitate the voluntary adoption by commercial fishers of new/modified fishing gear or fishing practice, including efforts to reduce environmental impacts and increase efficiency and profitability?

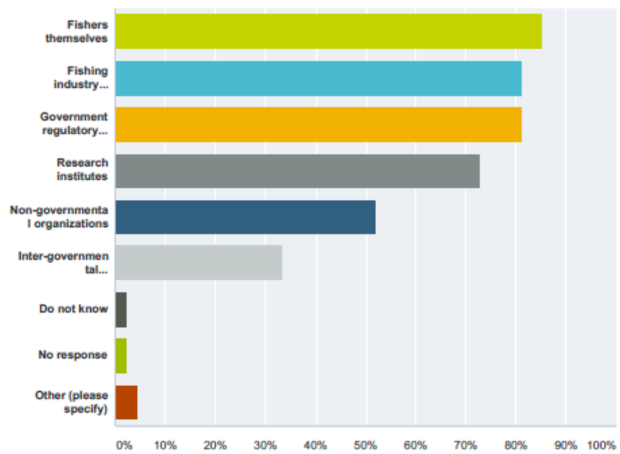
Answered: 48 Skipped: 0



Answer Choices	Responses	
Yes	72.92%	35
No	20.83%	10
No response	6.25%	3
Total		**48**

Q9 Who do you think is responsible for working with commercial fishers to facilitate their voluntary adoption and use of new/modified fishing gear or fishing practice, including efforts to reduce environmental impacts and increase efficiency and profitability? Please indicate all responses that apply.

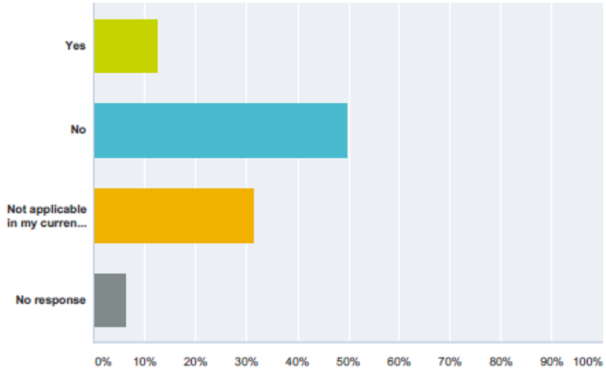
Answered: 48 Skipped: 0



Answer Choices	Responses	
Fishers themselves	85.42%	41
Fishing industry organizations/cooperatives	81.25%	39
Government regulatory bodies/agencies	81.25%	39
Research institutes	72.92%	35
Non-governmental organizations	52.08%	25
Inter-governmental organizations	33.33%	16
Do not know	2.08%	1
No response	2.08%	1

Q10 When facilitating change in fisheries, do you use a formal or recognized model of organizational change?

Answered: 48 Skipped: 0



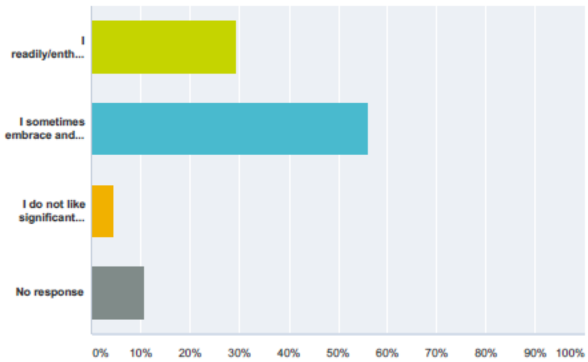
Answer Choices	Responses	
Yes	12.50%	6
No	50.00%	24
Not applicable in my current position	31.25%	15
No response	6.25%	3
Total		48

Q11 If yes, please identify or describe (briefly) the model of organizational change.

Answered: 5 Skipped: 43

Q12 In your current employment position, which of the following statements best describes your personal attitude to significant change? In this context, significant change could be in response to any crisis, threat, or major problem affecting your organization, or to an identified opportunity that could substantially alter the vision, direction, structure, or output of your organization.

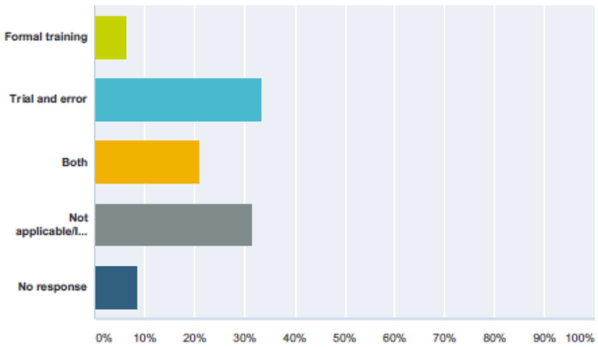
Answered: 48 Skipped: 0



Answer Choices	Responses	
I readily/enthusiastically embrace and accept significant change in my position	29.17%	14
I sometimes embrace and accept significant change in my position	56.25%	27
I do not like significant change and rarely/reluctantly accept significant change in my position	4.17%	2
No response	10.42%	5
Total		48

Q13 How did you develop your strategy for facilitating organizational change in the fishing industry?

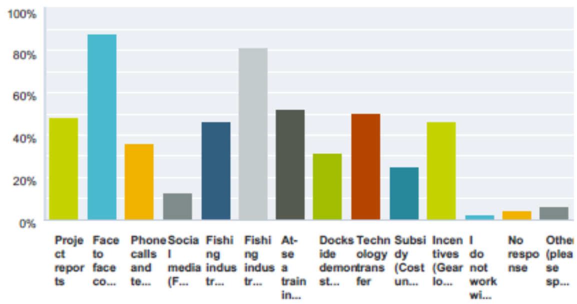
Answered: 48 Skipped: 0



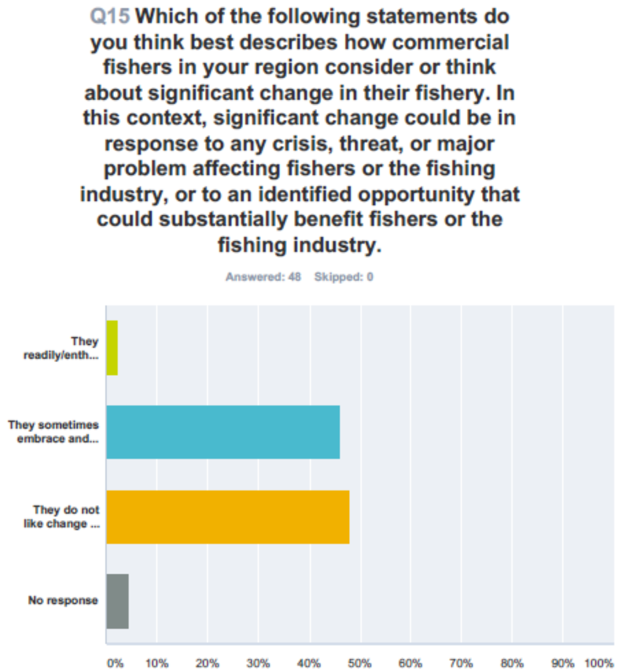
Answer Choices	Responses	
Formal training	6.25%	3
Trial and error	33.33%	16
Both	20.83%	10
Not applicable/I do not have a strategy	31.25%	15
No response	8.33%	4
Total		**48**

Q14 When working with commercial fishers, what core tools would you normally rely upon to bring about change in the fishing industry? Please indicate all responses that apply.

Answered: 48 Skipped: 0



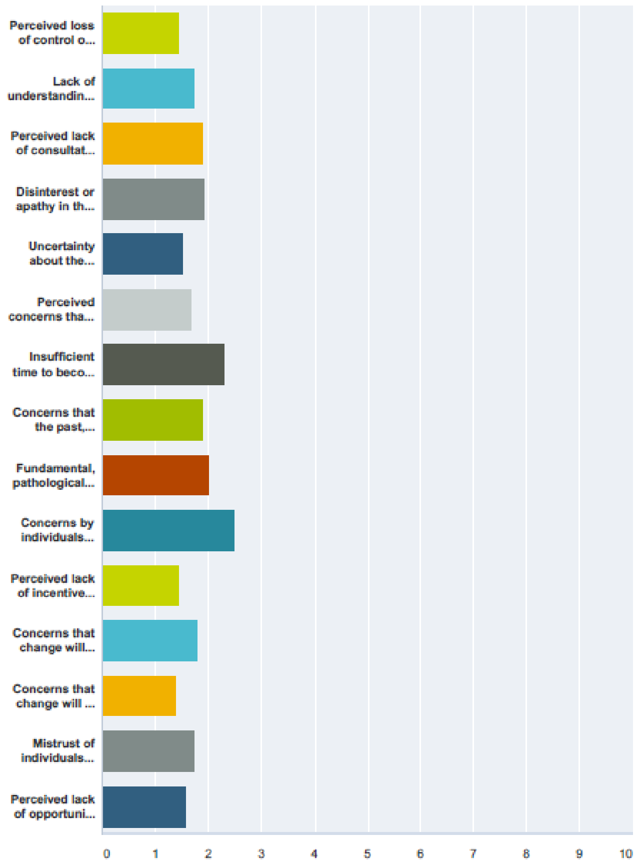
Answer Choices	Responses	
Project reports	47.92%	23
Face to face communication with fishers	87.50%	42
Phone calls and text messages to fishers	35.42%	17
Social media (Facebook, twitter, etc)	12.50%	6
Fishing industry publications and literature	45.83%	22
Fishing industry meetings/workshops	81.25%	39
At-sea training on fishing boats	52.08%	25
Dockside demonstrations	31.25%	15
Technology transfer	50.00%	24
Subsidy (Cost underwriting)	25.00%	12
Incentives (Gear loans, fishing opportunities)	45.83%	22
I do not work with fishers	2.08%	1
No response	4.17%	2
Other (please specify)	6.25%	3
Total Respondents: 48		



Answer Choices	Responses	
They readily/enthusiastically embrace and accept significant change in their fishery	2.08%	1
They sometimes embrace and accept significant change in their fishery	45.83%	22
They do not like change and rarely/reluctantly accept significant change in their fishery	47.92%	23
No response	4.17%	2
Total		48

Q16 For each statement below please indicate why you think some fishers are resistant to significant change. In this context, significant change can be in response to a crisis, major problem, or an identified significant opportunity for fishers. Responses to these statements are optional.

Answered: 44 Skipped: 4



Q17 Please insert any reasons why you think commercial fishers resist significant change.

Answered: 15 Skipped: 33

	Very important	Important	Not important	Total	Weighted Average
Perceived loss of control over their fishing operation and/or fishing business.	69.05% 29	19.05% 8	11.90% 5	42	1.43
Lack of understanding of the need or reason for change	37.21% 16	51.16% 22	11.63% 5	43	1.74
Perceived lack of consultation during the change process.	33.33% 14	42.86% 18	23.81% 10	42	1.90

Disinterest or apathy in the face of change.	26.83% 11	53.66% 22	19.51% 8	41	1.93
Uncertainty about the future, including how they might be influenced or affected by change.	59.52% 25	30.95% 13	9.52% 4	42	1.50
Perceived concerns that change will affect fishers unevenly.	50.00% 21	33.33% 14	16.67% 7	42	1.67
Insufficient time to become adjusted to the idea of change.	16.67% 7	38.10% 16	45.24% 19	42	2.29
Concerns that the past, including previous change efforts, will be ignored or dishonored.	28.95% 11	52.63% 20	18.42% 7	38	1.89
Fundamental, pathological, or ideological resistance by individuals to change.	30.23% 13	39.53% 17	30.23% 13	43	2.00
Concerns by individuals that they will appear incompetent in the face of change.	7.32% 3	36.59% 15	56.10% 23	41	2.49
Perceived lack of incentives to offset any catch loss.	60.47% 26	37.21% 16	2.33% 1	43	1.42
Concerns that change will have a ripple effect and more changes will be introduced.	38.10% 16	45.24% 19	16.67% 7	42	1.79
Concerns that change will be costly or painful.	64.29% 27	33.33% 14	2.38% 1	42	1.38
Mistrust of individuals responsible for bringing about change, including their motivation.	35.71% 15	54.76% 23	9.52% 4	42	1.74
Perceived lack of opportunity, benefit, or reward from change.	51.22% 21	41.46% 17	7.32% 3	41	1.56

Q18 Please insert any other thoughts or comments you might have on the topic of facilitating significant change in the commercial fishing industry.

Answered: 20 Skipped: 28

8.6.5 Summary of TG meeting in Lisbon, Portugal (2015)

WGFTFB Topic Group: Application of Change Management in the Fishing Industry

Conveners: S. Eayrs (USA) and M. Pol (USA)

8.6.5.1 General Overview

The topic group (TG) on Change Management in Fisheries met for the first time in Lisbon on Wednesday, 6 May 2015. Fourteen people participated for part or all of the meeting. Participants represented a wide range of experience, ranging from newly employed to greater than 40 years, and included work in large and small-scale fisheries globally. In plenary, results from a survey of WGFTFB members eliciting experience and attitudes toward change management in fishing technology were presented as a general invitation to the WG. In the TG, the agenda, purposes, scope and objectives of the TG were introduced, followed by a presentation on types of change, discussion about factors affecting change in the fishing industry, an introduction to some models of change, and discussion about the challenges of facilitating change in the fishing industry.

To set a foundation for the TG, S. Eayrs presented the Kotter model for change management. This model has been globally used in the business world and is considered applicable to the fishing industry. The presentation of this model provided an opportunity to review and comment on its applicability. Three formal presentations were also heard regarding individual or group experience with change, followed by individual brief examples of experience facilitating change by participants.

The group discussed the applicability of the Kotter change management model and any other models or frameworks that had been used to facilitate change; the group was unable to conclude that any particular model fit better than the others. No experience was found where change in fishing fleets was managed with any change management model other than ad hoc ones derived from experience. Examples were cited of very rapid change by fishers, but no clear or consistent drivers for rapid uptake could be discerned. It was clear that banning of gear or closure of fisheries can incentivize change, but the enthusiasm and cost efficiency of change in these situations was questioned. The role of incentives, particularly but not exclusively, money, was also discussed. Examples were provided where financial incentives to fishers had not facilitated change or encouraged adoption of fishing gear. A need was identified to assess the utility of the Kotter model to known examples of success. A plan was developed for the intersession and for next year, whereby individuals would evaluate the performance of a change initiative they were involved in against the Kotter model. It was proposed that the topic of change management in fisheries be considered for a mini-symposium topic for the FAO section of the 2016 meeting.

8.6.5.2 Terms of Reference

A WGFTFB TG convened by Steve Eayrs (USA) and Michael Pol (USA) will be formed in 2015 to evaluate the application of organizational change management concepts and models in a fisheries context and recommend new approaches to overcome resistance to change in the fishing industry.

The terms of reference will include:

i) Evaluate the applicability of organizational change management concepts and models in a fisheries context

ii) Review and evaluate fisheries case studies and initiatives to bring about change

iii) Explore models of human behavior that may contribute to resistance to change

iv) Identify and categorize circumstances and approaches that led to both the successful and unsuccessful introduction of change initiatives in fisheries.

Justification:

Despite efforts by fishing technologists, conservation engineers, and others to increase fishing efficiency and reduce environmental impacts, commercial fishers are often highly resistant to changing their fishing gear and practice. In the business world, responses to change are increasingly being guided by organizational change management concepts and models, however, their application to the fishing industry has been scant, piecemeal, and incomplete. These concepts and models provide greater understanding of resistance to change and could provide an insight into new approaches to facilitate change in the fishing industry. By reviewing organizational change management literature, as well as past efforts to facilitate change in fisheries, we hope to identify circumstances, models, techniques, and approaches that will result in smoother, cost-effective, and successful change initiatives in the fishing industry in future.

8.6.5.3 List of Participants

Name	Institution	Country
Steve Eayrs	Gulf of Maine Research Institute	USA
Michael Pol	Massachusetts Division of Marine Fisheries	USA
Ulrik Jes Hansen	Catch-Fish	Denmark
Pingguo He	SMAST. University of Massachusetts Dartmouth	USA
Aida Campos	IPMA	Portugal
Thomas Moth-Polsen	FAO	Turkey
Petri Suuronen	FAO	Italy
Rikkie Frandsen	DTU-Aqua	Denmark
Thomas Noack	DTU-Aqua	Denmark
Ismet Saygu	Cukurova Univeristy	Turkey
Arne Kinds	ILVO	Belgium
Daniel Aguilar	INAPESCA	Mexico
John Willy Valdemarsen	IMR	Norway
Tereza Fonesca	Southwest Western Atlantic Advisory Council	Portugal
Leela Edwin (by mail)	CIFT	India

8.6.5.4 Agenda

Time	Activity	Chair
0840	Introduction – Agenda, purpose, scope, and objectives of TG; House-keeping (Eayrs)	Eayrs
0900 -0915	Introduction of participants and interest in TG (All participants)	Pol
0915 -1000	Setting the scene: Types of change; Factors that affect change in the fishing industry, incl. prospect theory, introduction to the Kotter model (Eayrs)	Pol
1030-1050	Coffee	
1050 -1110	Tracking the Evolution of Ring seine Fishing System of India and Interventions to ensure sustainability of the fishery (Edwin, L. *et al.*)	Pol
1110 – 1130	VALDUVIS: integrated sustainability assessment by a cost-effective use of existing data and science-based indicators, affordable to any scale of fishery (Kinds, Arne. *et al.*)	Pol
1150 -1230	Case studies and initiatives to bring about change – oral reports (All participants)	Pol
1230-1330	Lunch	
1330 -1400	Case studies and initiatives to bring about change – oral reports (All participants)	Pol
1400 -1500	Lessons learned from case studies/general discussion The role of incentives in achieving outcomes The influence of impending legislation/regulation on the response and reaction of fishers How trust-building was an integral component of the initiative (or not) How fear of financial/other loss influenced their reaction and response.	Pol

1500-1520	Coffee	
1520	Categorization exercise: Are their core characteristics of a fishery or fishers that increase resistance to change? What are essential components of a change initiative? What can we learn from the questionnaire? Are industrial fleets more accommodating of change compared to owner/operator or subsistence fleets? Are we in agreement with change terminology? How relevant is the Kotter model in a fishery context? Other models? Do we need external expert advice?	Eayrs
1630	Wrap up discussion, next steps and future activity, and concluding remarks.	Eayrs/Pol
1700	End	

8.6.5.5 Presentations

8.6.5.5.1 Questionnaire Results (S. Eayrs)

This presentation was presented during the plenary session in order to report the results of a questionnaire open to the Working Group and to set the scene for the TG on change management in fisheries. The following is summary and interpretation of questionnaire data.

Prior to the meeting in Lisbon members of the Working Group were invited to complete a brief questionnaire in order to learn about their attitudes and approaches to change in the commercial fishing industry. The online survey tool Survey Monkey was used to administer the questionnaire and each member was provided an online link to questions.

Over a period of 6 weeks a total of 48 responses were received. At the time of this presentation in Lisbon 31 members had responded, however, as the tool was open until 22 May, the following results are based on responses received up to 22 May. For the sake of brevity, written comments are not included in this summary.

A total of 32 respondents (66.7%) considered themselves to be fishing technologists, while the remainder were fisheries biologists, ecologists, or held other positions. Most respondents were employed by the government (44%), followed by academia (28%), non-governmental (8%), and intergovernmental (6%). Just over a quarter of respondents had been employed in their current position for 5–10 years (27%) while a quarter had been employed for 21 years or longer. Approximately 21% of respondents had been employed for less than five years in their current position and 21% had been employed for 11–15 years. In contrast, almost 38% of respondents had been employed for over 21 years in any capacity in the fishing industry. Most of the remaining respondents had been employed for 15 years or less.

Just over 83% of all respondents indicated it is one of their current roles or duties to work with fishers and assist their adoption and use of new or modified fishing gear due to *regulation or mandatory* change. Only 73% of respondents thought it was their role or duty to help fishers *voluntarily* adopt and use new or modified fishing gear. Over 80% of respondents felt it was the duty of fishers, fishing industry organizations and the government to help fishers adopt and use new or modified fishing gear due to *regulation or mandatory* change and to facilitate their voluntary adoption of and use new or modified fishing gear. Despite a large proportion of respondents feeling it was their duty to work with fishers to facilitate change, 50% of them do not use a formal or recognized organizational change model and almost one-third felt it was not applicable in their current position. Only 6% of respondents indicated they have had formal training to develop their strategy for facilitating organizational change, while just over 30% indicated they apply a trial and error approach to facilitating change in the fishing industry and another 30% felt it was not applicable or did not have a strategy.

Just over 56% of respondents indicated they sometime embrace and accept significant change in their position and almost 30% indicated they do not like or accept significant change in their position. In contrast, 48% felt fishers do not like or accept significant change and 46% indicated they sometimes embrace and accept significant change.

Over 80% of respondents indicated they use face to face communication with fishers and industry meetings and workshops to bring about change in the fishing industry. Around half of the respondents indicate they use project reports, fishing industry publications and literature, at-sea training, technology transfer and incentives to bring about change. Only 13% of respondents indicating using social media to bring about change.

In response to the question regarding why they thought fishers were generally resistant to significant change, respondents most commonly selected: *Concerns that change will be costly or painful*; *Perceived lack of incentives to offset catch loss*; *Perceived lack of control over their fishing operation or business*; *Uncertainty about the future and how they might be affected by change*; and *Perceived lack of opportunity, benefit, or reward from change* as the primary reasons for their resistance. *Concerns by individuals that they will appear incompetent in the face of change*, and *Insufficient time to become adjusted to the idea of change* were the least commonly selected responses.

In conclusion, the questionnaire has confirmed that most respondents were fishing technologists that have been involved in the fishing industry for a long time. The application of formal change management models is virtually non-existent and we have had little or no training in this topic. We feel that fishers, fishing industry groups, government should play a leading role facilitating change with fishers, both in response to regulation or voluntarily. We prefer face to face contact with fishers including meetings and workshops to facilitate change, and we feel concerns over increased expenses, loss catch and control, uncertainty, and lack of reward are core drivers for the resistance by fishers to change.

8.6.5.5.2 Setting the Scene: Can a new approach to change in commercial fisheries provide additional benefit to fishers and others? (S. Eayrs)

A key goal of conservation engineering research is to encourage significant or revolutionary change in a fishery, such as fishers using new fishing gear, their compliance to seafood certification requirements, and the introduction of new regulations pertaining to fishing gear design and operation. However, in many instances, such changes are resisted by fishers (and other stakeholders) and their appetite for change is low.

This resistance is somewhat paradoxical considering commercial fishers operate daily in an environment that is highly variable and often unpredictable. They literally work in an environment that is perpetually changing, and their fishing success requires them to respond and adapt to changes in this environment. Their success also depends on an ability to adapt to variation in catch volume and composition, fishing costs, market prices, and numerous fishery regulations and amendments. Despite a plethora of influencing variables, and their persistence and their influence on fishing success, change is seldom embraced by fishers. This contradiction in behavior, where fishers respond to change but also resist change, can be called *The Paradox of Fishermen*.

The rationale for this paradox is not well understood. However, it does challenge the ability of researchers, managers, and others to work with fishers and facilitate needed change in the fishery. To better understand *The Paradox of Fishermen* and foster a more dynamic and receptive environment for change, a new way of thinking about fishers and change seems necessary, one that is underpinned by an understanding of the theory and principles of organizational change management.

At a fundamental level, organizational change management is about ensuring the survival of an organization that is surrounded and influenced by a variable, discontinuous, capricious, and often unpredictable external environment. It is often focused on people, structure, processes, or technology, and aims to bring about significant cultural change within an organization. For those attempting to facilitate organizational change, a variety of change management models exist to facilitate, guide, and manage the process of instituting desired change.

Change management models often strive to distinguish between two types of change, one that has a significant effect on an organization and the other having a lesser effect. Change that has significant impact on an organization is often referred to as *revolutionary change*. This type of change is planned to revolutionize or transform an entire business or organization and improve performance. Revolutionary change is radical, intense, episodic in nature, and strategically applied. In the fishing industry, revolutionary change occurs when fishers are required to alter fishing practice to comply with significant change in fishery regulations, for example, the replacement of input controls with output controls. In this instance the change may require fishers to significantly modify or replace their fishing gear or behavior, especially if 'choke' species limit access to other quota species, and is planned to significantly influence most or all participants in the fishery. Usually this change is associated with turmoil, and although it can occur quickly, its effects are long lasting because the goal is irrevocable change.

Change that has a lesser effect on an organization is referred to as *evolutionary change*. This type of change occurs relatively continuously, in increments, and gradually over a period of time. Evolutionary change is also characteristic of most change efforts, including those designed to improve performance or efficiency, and while it does not normally set out to change the culture or fundamental nature of an organization or business, it can eventually provide broad and lasting changes with little disturbance. Most change that has occurred in the fishing industry can be considered evolutionary.

The Kotter model of change management was then presented. The Kotter model is an eight-step process that has been used to guide many corporations both nationally and internationally through the process of introducing and cementing revolutionary change (Figure 8.2.1). The Kotter model is a response to eight commonly observed errors to establish permanent change. The first and biggest error is to attempt change without establishing a sense of urgency. This results in lack of enthusiasm and complacency, and always leads to a failure in bringing about hoped-for change to the fullest extent practicable.

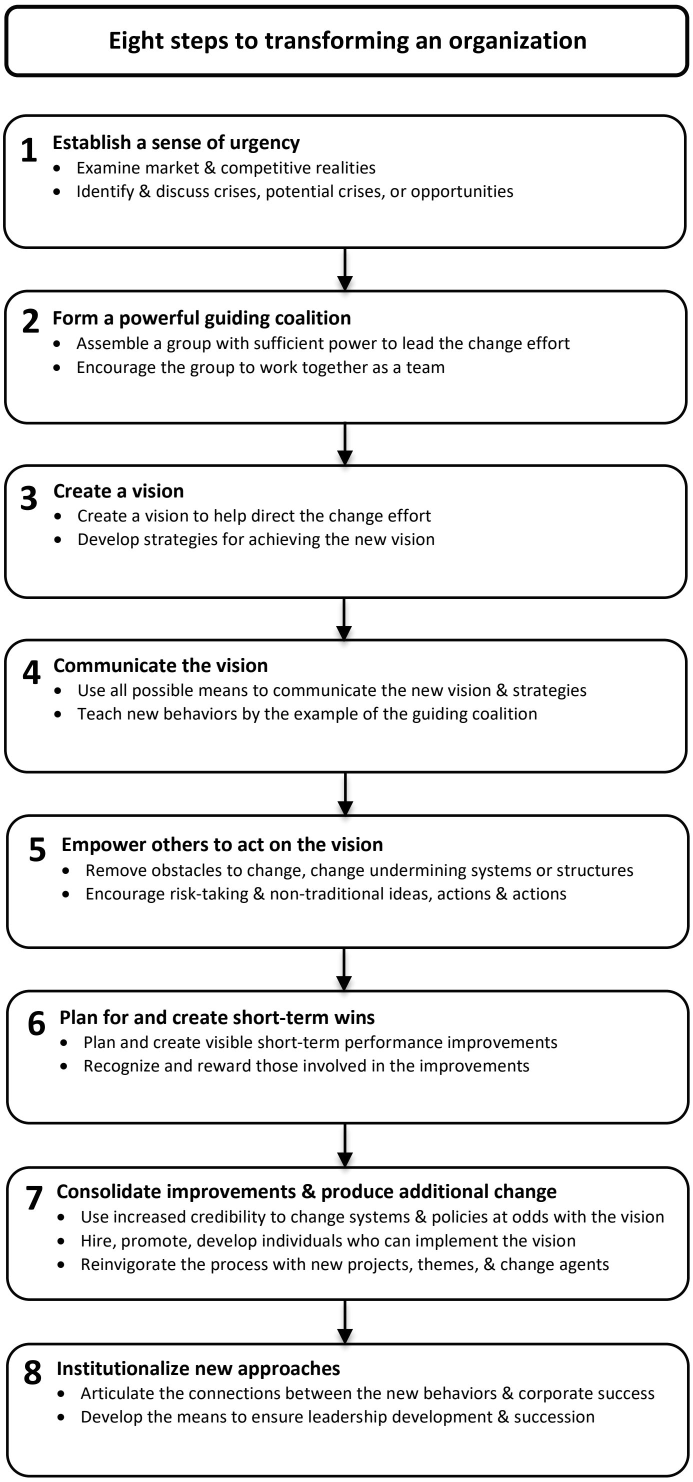


Figure 8.2.1. Kotter's eight-step change management model. (Adapted from Kotter, 1996.)

For example, a lack of buy-in by fishers for new fishery regulations means they will reluctantly acquiesce to change and not fully apply themselves. The second error is to create an insufficiently powerful guiding team or coalition that lacks credibility, expertise, and leadership to create a climate for change.

Individuals alone seldom have the competency and charisma to sufficiently create long-lasting change and a powerful coalition is essential. In many fisheries, fishing fleets are poorly organized and there is little collaboration between fishers to optimize outcomes. The independent nature of fishers is a substantial contributor to poor collaboration. Ideally, the guiding coalition should comprise a diversity of fishers affected by a proposed change, preferably including representatives of all fishing methods, boat sizes and types, and old hands and new. The identification and engagement of early-adopters is essential at this point. The third error is underestimating the power of vision to guide and inspire individuals to change. The vision must be clear, concise, and easily articulated. Failure to overcome any of these three errors almost always leads to failure because the appropriate climate for change has not been established.

The fourth error is under communicating the vision. Change will not occur if people do not believe the benefits of change are attractive and that revolutionary transformation is possible. Communication, both verbally and through actions, is vital and requires a committed, sustained, and coordinated effort. Fishers are sometimes parochial in their communication and beliefs, and so gaining their support for change requires a substantial undertaking. Failure to do so risks rumor and innuendo spreading throughout the fleet. Furthermore, if fishers are witnessed ignoring or circumventing the change initiative the enthusiasm of other fishers will be challenged and the initiative is likely to fail. The fifth error is permitting obstacles to block the new vision. These obstacles may be based on perception, emotion such as fear or anxiety, parochialism, or, due to business structure, practice, or culture. Again, the nature of some fishers may make it very difficult to overcome this error (although in many instances regulatory complexity and rigidity of many fishery management systems is also a major obstacle to change), and a key challenge is overcoming how these obstacles influence radio or dock-side conversation between fishers. Therefore, a major role of the guiding coalition is to turn around this negative ‘chatter’ and increase the frequency of positive communication.

The sixth error is failing to produce short-term wins early in the change process. These wins may be in the form of increased salary, profit, or reward, and are essential because they serve to encourage individuals to stay the course and maintain momentum. In a fishery this success might be in the form of increased landings or catch value, reduced fuel consumption (although in the New England groundfish fishery some fishers deem this of lesser importance than other factors), or increased access to fishing grounds or fish stocks. Such success is also likely to lead to better buy-in, communication, and participation by fishers. Committing errors four, five, or six risks an inadequately engaged or allowed individual or organization and will compromise potential for change.

Error seven is to declare victory too soon and lose momentum. This occurs when change initiatives are successful and resources are then redirected elsewhere prior to the change being fully embedded into the culture of an individual or organization. The final error is to actually fail to deeply embed changes into the culture of an individual or organization; only when a new behavior becomes a norm is it likely to be cemented in place and prevent regression. In a fishery, this may require providing fishers adequate time and opportunity to learn and become comfortable using new or modified fishing gear over a range of operating conditions, and to pass on their findings to other fishers.

The core challenge in all eight stages of Kotter's model is changing people's behavior. An underlying premise underpinning the model is that people change because they are shown a truth that influences their feelings and less so because they are given analysis that influences their thinking. Strong leadership rather than management is key. Kotter argues the mantra of '*See, Feel,* and *Change*' must be applied within each of the steps to bring about effective change, and that this is significantly more powerful than the traditionally applied, '*Analyze, Think,* and *Change*' approach.

Comments

How does FAO experience with TEDs in Nigeria fit or not fit the Kotter model? The group had some disagreement on the success level of this effort and current usage by Nigerian fishers remained unclear.

8.6.5.5.3 Tracking the Evolution of Ring seine Fishing System of India and Interventions to ensure sustainability of the fishery: L. Edwin (India), presented by M. Pol

The adoption and proliferation of ring seine (mini-purse-seine) among the traditional fishers is considered as the most significant change in the post motorization era of fisheries of the southwest coast of India. In 2012, this fishery contributed 18.3% of the marine fish landings of the country. The ring seine gear was first introduced by the Central Institute of Fisheries Technology (CIFT), Cochin in the mid-1980s as a new gear for the traditional sector which was marginalized by the emerging mechanized sector. At the time of introduction, the size of ring seine was 250 m in length and 33 m in depth, and was designed for operation from the traditional plank built canoes. Fishers welcomed the new fishing method as it assured them a large quantity of catch compared to their conventional fishing methods. Widespread adoption of this technology resulted in substantial increase in the landings of small pelagic species like oil sardine, mackerel and anchovies by the traditional sector. By the end of the eighties, ring seine became the principal gear for the exploitation of pelagic fish resources along the coast of the state of Kerala and it later spread along the entire southwest coast of the country. A recent survey conducted by CIFT in 2012–2013 on the marine fishing systems of India show that this technology has spread along the west and east coast of the country except in the state of West Bengal. The same study revealed that the dimensions of this gear have increased at least three to four times to about 1000 m in length and 100 m in depth. The success of this fishing method attracted more fishing units to this fishery. In order to accommodate the huge gears the fishing vessels also increased in size and number of craft forming a single fishing unit increased to as many as four. The uncontrolled growth in the size of the fishing unit (from 6 to 24 m LOA), increased number of units (>2500 in place of 300) and large crew (12 to 60) onboard, questions the continued sustenance of this fishing method. The horsepower of the engines increased from 9.9 hp to >600 hp in tune with the increasing size of craft and gear, larger crew size and bulky catch. The huge capital investment, high operational costs, increased number of non fishing days and excess labor have forced many units to limit fishing to peak season alone. Studies revealed that 90% of the operational expenditure of the larger units is on fossil fuel which also increases carbon emissions. Scientific advisories and government regulations to curb the unbridled growth of the fishing system did not have any effect on the management of this fishery.

In this context, an optimized ring seine was designed by downsizing the gear, in consultation with the fishers, and demonstrated by CIFT on an experimental basis but adoption was restricted to three districts only. The operational efficiency of the gear with respect to sinking speed, durability has been studied and through substitution by an alternate material a further improved design is proposed by the institute. Meanwhile, realizing the non - viability of the large units the fishers themselves have come up with a miniature model of the large encircling gear, of about 100 m in length, which is being operated from small canoes and is gaining fast acceptance. It is reported that 60% of the ring seine fishers of Chellanam fishing village, have turned back to the small fishing units. The Life Cycle Assessment and Carbon footprint of the new gears compared with the larger conventional ring seines is also discussed in this communication. Theoretical calculation shows that the Life Cycle Assessment (Global Warming Potential for 100 years) for the design proposed by CIFT is 60% lesser than the conventional large ring seine. The tracking of the growth and evolution of this gear has once again proved that the success of scientific interventions depend solely on the 'bottom up' approach.

Comments

A group member noted that top–down approaches to change are not always effective and carry special risk.

8.6.5.5.4 VALDUVIS: integrated sustainability assessment by a cost-effective use of existing data and science-based indicators, affordable to any scale of fishery – A. Kinds (Belgium)

Numerous seafood guides, labels and certification schemes have emerged over the past decades, and their number is still growing. Although with the best intentions to inform consumers about sustainable seafood choices, this excess has often resulted in consumer confusion (Jacquet and Pauly, 2006). Since recently, however, considerable effort is being put into aligning and benchmarking these initiatives (e.g. Vos *et al.*, 2010; Food & Water Europe, 2011; Sys, 2013; Melissant *et al.*, 2014). Pressure groups are lobbying for a European standard for sustainable seafood based upon the FAO guidelines for aquaculture and fisheries certification, instead of leaving it to private labels (e.g. Food & Water Europe, Brot für die Welt).

On top of the need for aligning and benchmarking existing certification schemes, the Institute for Agricultural and Fisheries Research (ILVO) calls for a rethinking of data gathering and a broader reach of these schemes. Certification schemes either focus on consumers (e.g. Friend of the Sea, the Marine Stewardship Council) or on businesses (e.g. Label Rouge, GLOBALG.A.P.), but hardly ever the same standards are used to inform both.

There is a growing demand for sustainably caught fish on the Belgian market. However, retailers are now importing sustainable (labeled) fish from Iceland or Norway, as sustainability information for Belgian fisheries is lacking. Sustainable seafood guides (e.g. de VISwijzer) offer a handy tool for the environmentally conscient consumer, but are not accepted by the Belgian fishing sector because they use generalized information to score fishing techniques. On the sector's demand, we have developed a set of indicators and a scoring system (called VALDUVIS) that takes into account local characteristics and uses of fishing gears, gear adaptations and socio-economic aspects of the fishery. The system is developed in such a way that it is ready for use in other European member states.

The VALDUVIS method (Valorisation of Sustainably Caught Fish) constitutes a holistic and fairly cheap approach to assess the sustainability of a fishing trip. Under EU legislation, fisheries data collection is organized. As such, fishers use an electronic logbook system to report their catches to their local governments. VALDUVIS uses these data sources to automatically generate sustainability scores, which are available to fish mongers soon after landing the catch. Socio-economic indicators are calculated on a quarterly or yearly basis. By using an existing and reliable data sources, VALDUVIS goes past the issue of the high audit costs of most schemes. VALDUVIS thus generates an invaluable source of information that can be used by fishers, researchers, policy-makers, retailers, certification bodies, etc. to communicate about sustainability in the same standardized way. VALDUVIS is an information tool that can be used in various ways, depending on the needs of the users. Great emphasis is placed on stakeholder participation and most notably feedback to and from fishers.

ILVO wants to take a lead in aligning sustainability standards and in making reliable sustainability information accessible throughout the production chain. The aim of the sustainable seafood movement goes beyond demonstrating best practices to obtain a better price or improved market access. The goal is a worldwide shift towards sustainability, which cannot come from private initiatives alone (Kaiser and Jones, 2006; Jacquet *et al.*, 2009).

8.6.5.5.5 Confessions of a developer (Ulrik Jes Hansen)

This presentation served as a personal retrospective covering a long and storied history working with fishers and developing fishing gear. It was noted that Ulrich's perspective is relatively unique, as it is from a commercial angle, someone who makes a living from working closely with fishers, and who has tried every promotional means. Yet, despite his long experience, and substantial promotion of innovations, uptake has been spotty and unpredictable (Table 8.6.1). Reasons for this lack of uptake are unclear and have never been fully understood.

8.6.5.6 Discussion

It was commonly observed that long experience working with the fishing industry has not provided any easy answers to facilitating change with fishers. It was estimated that the cumulative experience with the fishing industry exceeded 200 years, yet almost universally, TG participants cited experiences where fishers had strongly resisted change.

Several core themes, conclusions, or points for future consideration were identified:

- Consideration should be given to differences in the type of change ie. revolutionary (transformational) change or evolutionary (incremental) change and that types of change should be considered from the perspective of the change recipient.
- The validity and utility of bottom–up, fishers-driven models and top–down scientist/manager driven change initiatives was discussed.

Table 8.6.1: Key developmental activities with fishers, outreach type, and outcome.

Activity	Outreach/promotion	Outcome
Twin trawl development	Flume tank demonstrations Instructional pamphlets with measurements Papers, magazine articles Report	Most Danish fishers converted within first year
Twin trawl development	Seafood NZ magazine Newspaper/media Annual Seafood Conference	Not adopted by New Zealand fishers

Activity	Outreach/promotion	Outcome
	Report Word of mouth	
Y trawl development	Full-scale trials Flume tank demonstrations Training courses and lectures Fishing papers and magazines Fishing exhibition Report	Not adopted. Too complicated, few understood
Flume tank courses by video link	Fishing exhibitions Fishing News International Tank demonstrations to Norway, Iceland, and the US	No interest; participants wanted to travel to tank facility
Energy efficient trawl development (flying doors, net redesign, drop meshes, T90 in belly and codend	Fishing News International Magazine articles in Denmark, Norway, Poland, Iceland, Argentina, Australia, etc. Conferences in FTFB, Denmark, Spain, Iceland, Bangladesh, Mexico	Limited uptake; too complicated, few understood
T90	Full-scale trials Flume tank demonstrations Training courses and lectures Fishing papers and magazines Reports (refereed) Pamphlets, brochures Conferences	Limited adoption
Plate gear	Full-scale trials Flume tank demonstrations Fisheries exhibitions Fishing papers and magazines Video (free) Conferences	Limited adoption; too complicated, too early?
Oyster dredge	Full-scale trials Flume tank demonstrations Reports	Too cumbersome? No! Negative attitude from users despite threats of closure

- It was pointed out that a risk of bottom–up initiatives is that an initial, bad, experience by fishers may deter future efforts by the same fishers to facilitate refinement of the gear, testing of new gear, or involvement in another change initiative. These outcomes clearly present a risk to the success of projects with fishers. The unpredictability of timing and the capacity for fishers to accept change was also cited.

- Incentives, particularly money, were cited as necessary for uptake, including understanding the motivation of fishers. The proper alignment of these incentives was seen as key, but counter examples were also cited whereby seemingly significant financial incentives were larger ignored by fishers and the hope-for change did not occur. Examples were also cited where the benefits of a new gear were not seen to be harvested by those that bore the costs (reduced catch, for example) of the gear. Further along these lines, the necessity to understand who the stakeholders are was cited: targeting owners when they are not captains, for example. Also, noting that representatives of fishing groups sometimes make decisions for fleets than are not acceptable to fishers.
- The requirement and tendency toward economic privacy may inhibit development of an appropriate economic incentive. Since access to economic data are restricted, it is difficult to find out or to verify if a change would be profitable or not.
- The role of trust, or lack of trust, with fishers was cited. Management systems erode trust by endorsing schemes and regulations that seem absurd to fishers or undercut their sustainability. Where historical sacrifices by fishers are unrecognized by change agents or have gone unrewarded, further change may be impeded by these same fishers.
- The self-image (or imposed image) of fishers as experts was discussed. It was questioned whether fishers bear a social cost if they are open to change, and examples were identified where the economic viability of fishers was admitted privately but not publicly.
- It was noted that in an unpredictable environment, doing nothing or waiting might be an excellent strategy for fishers to adopt to resist change, in the hope that it might go away. Also, the unpredictable nature of fishing (tow-to-tow, or year-to-year) might imply that rewards for uptake might need to be much higher than previously thought. It was noted that where ecosystem productivity is high, the impact of over exploitation or the benefits of gear uptake might be obscured, as shifts to other species were easy.
- The expected time-scale and frequency of change was discussed. Is five years too short a time-scale? Is change generational – does it only really happen, or most commonly, with new entrants to the fishery? What frequency of success should be expected for change efforts?
- GAP2 and ECOFISHMAN were cited as big EU projects that might have considered a change management system. These projects should be explored in readiness for the meeting next year, and consideration given to inviting speakers from these projects.

8.6.5.7 Main outcomes

1) No examples of the use of change management models to facilitate implementation of new gears or other fishery changes was found. Only self-developed ad-hoc models have been used by the TG.
2) Approaches to facilitate change taken by TG individuals varied greatly, and varied in success.
3) Examples of rapid uptake of gears were described, including the Nordmore grid and the twin trawl, but no clear methodology or explanation for these examples was described.

4) Closing a fishery or other drastic action can be a strong motivation for uptake, but concern was raised that this type of incentive can result in unenthusiastic and superficial embrace of the change.
5) The importance of incentives was identified, but a lack of clarity about the role of money or other forms of incentive was identified.
6) The validity or utility of the Kotter change management model could not be adequately assessed in the time available. Therefore, a need to examine case studies using the Kotter model was identified.

8.6.5.8 Recommendations

1. The group will work intersessionally applying the Kotter model to examples of change in fisheries that they have personal familiarity with. Individual members volunteered to take on this task.
    a) GEARNET (Eayrs)
    b) Raised footrope trawl (Pol)
    c) Grids in Denmark (Frandsen)
    d) Twin trawling (Hansen)
    e) Nordmore grid (He, Valdemarsen)
    f) VALDUVIS (Kinds)
    g) To be determined (Saygu)
2. The VALDUVIS project is underway, and Kinds will consider the application of the Kotter model to this project. Saygu will create a theoretical plan for implementation of the Kotter model based on a current project.
3. The topic will be put forth as a possible theme for the mini-symposium in 2016.
4. In 2016, the group will continue to work, including attempting to validate the Kotter model based on results of the intersession and any experiences described in the mini-symposium.
5. The group will consider ways to incorporate fishers' perspectives.
6. The group will solicit expertise from experts in social sciences, and explore their potential involvement in the 2016 meeting. Two candidates were identified: Alyne Delany from the Institute for Innovative Management (University of Aalborg); Marloes Kraan from IMARES.

8.6.6 Summary of TG meeting in Mérida, Mexico (2016)

WGFTFB Topic Group: Application of Change Management in the Fishing Industry

Conveners: S. Eayrs (USA) and M. Pol (USA)

8.6.6.1 Topic Group Summary

This meeting was the second of a three-year topic group on the application of change management in the fishing industry. It was attended by a total of 16 individuals from 10 countries. The purpose of this meeting was to retrospectively evaluate case studies related to change in the fishing industry against the Kotter model of change management, explore models of human behavior that may contribute to resistance to change, and identify and categorize circumstances and approaches that led to the successful and unsuccessful introduction of change in fisheries. Seven case studies were presented, although not all were evaluated against the Kotter model. The group also explored two additional case studies, which were also evaluated against the Kotter model.

The main outcomes of the topic group were:

1. Retrospective case studies identified some or all of the steps of the Kotter model, but no particular step was considered to determine success or failure.
2. Elements of successful change programs were suggested: size of the stakeholder group, stature of participants, clarity of purpose or vision, closures or lawsuits forcing mandatory change (AKA "the hammer"), and health of fishery resource or profitability of the fishery.
3. Vessel ownership (non-operator/corporate v. owner/operator) influences appetite and attitude toward change.
4. Readiness to change is an important element in understanding how change occurs, and can be a useful addition to the Kotter model, which focuses on inertia and process).
5. Simplification of regulations might engage fishers in useful innovation instead of harmful innovation.
6. Application of the Kotter model to two case studies highlighted the importance of a careful definition of the vision of a change initiative.
7. Contributions from social scientists with experience in human behaviour and the commercial fishing industry were agreed to be needed in order to validate and support our understanding of human decision-making.
8. ICES Strategic Initiative on the Human Dimension (SIHD) should be informed of topic group findings and explore opportunities for collaboration.
9. Preparation of an extensive retrospective review for publication that attempts to categorize circumstances and events that contribute to successful and unsuccessful change initiatives in fisheries should be considered.
10. The group should present final findings and conclude the topic group in 2017, while seeking opportunities for future investigation and study.

8.6.6.2 General Overview

The topic group (TG) on Change Management in Fisheries met for the second year in Mérida on Thursday, 28 April 2016. Sixteen people participated for part or all of the meeting. Participants represented a wide range of experience, ranging from graduate students to senior personnel, and included work in large and small-scale fisheries globally. A preceding session ("Session 2: Encouraging technological change in capture fisheries") convened by Eayrs and Pol as part of the FAO Symposium included six talks relevant to the TG, including a keynote by Eayrs on organizational change management that also introduced the TORs of the TG. In the one day available to the TG, the agenda, purposes, scope and objectives of the TG were introduced, followed by a series of presentations on application of the Kotter Model change management (Figure 8.2.1) model to instances of gear uptake or other change on historic or existing fisheries.

To set a foundation for the TG, Eayrs presented the agenda, purpose, scope, and objectives of the TG. He also summarized the 2015 meeting and intersessional action, and the Kotter model for change management. This model has been globally used in the business world and is considered applicable to the fishing industry. Seven presentations were heard by the group regarding the applicability of the Kotter model to past and current projects. Two case studies of imaginary or proposed activities were presented to subgroups and the Kotter model was used to test or to examine possible plans for implementation of these activities.

The retrospective application of the Kotter model gave some perspective on success or failure, although it was not found to be deterministic, nor was any one step of the model deemed crucial to success or failure; all were deemed important and necessary. A general discussion of possible motivations and explanations for resistance or willingness to change was conducted throughout the day, with economic rationality and discounting, the need for the appropriate size steering group, the health of the fishery, and the need for personal relationships and frequent contact all highlighted.

Future actions were left uncertain, because a need to involve social scientists to guide an understanding of human behaviour and decision-making is clear, but unfulfilled. If a social scientist is recruited for the TG in the following year, then the topic group will meet to discuss the third and fourth terms of reference; if not, either intersessionally or at the next TG meeting, a final report will be produced.

8.6.6.3 Terms of Reference

A WGFTFB TG convened by Steve Eayrs (USA) and Michael Pol (USA) will be formed in 2015 to evaluate the application of organizational change management concepts and models in a fisheries context and recommend new approaches to overcome resistance to change in the fishing industry.

The terms of reference will include:

i) Evaluate the applicability of organizational change management concepts and models in a fisheries context

ii) Review and evaluate fisheries case studies and initiatives to bring about change

iii) Explore models of human behavior that may contribute to resistance to change

iv) Identify and categorize circumstances and approaches that led to both the successful and unsuccessful introduction of change initiatives in fisheries.

Justification:

Despite efforts by fishing technologists, conservation engineers, and others to increase fishing efficiency and reduce environmental impacts, commercial fishers are often highly resistant to changing their fishing gear and practice. In the business world, responses to change are increasingly being guided by organizational change management concepts and models, however, their application to the fishing industry has been scant, piecemeal, and incomplete. These concepts and models provide greater understanding of resistance to change and could provide an insight into new approaches to facilitate change in the fishing industry.

By reviewing organizational change management literature, as well as past efforts to facilitate change in fisheries, we hope to identify circumstances, models, techniques, and approaches that will result in smoother, cost-effective, and successful change initiatives in the fishing industry in future.

It was noted that the first two terms were addressed the previous year in Lisbon, and that challenges with recruiting the assistance of a social scientist would limit our ability to address the third and fourth terms.

8.6.6.4 List of Participants

Name		Institution	E-mail
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8.6.6.5 Agenda

Time	Activity
0900–0915	Introduction – Agenda, purpose, scope, and objectives of TG; Housekeeping (Eayrs)
0915–0930	Introduction of participants
0930 – 1040	Summary of 2015 meeting (Eayrs) What role can organizational change management play in encouraging change in the New England groundfishery? (Eayrs) Technological change and the Kotter model: A case study with the raised footrope trawl (Pol) Reconversion of a trawler to a longliner to target black scabbard and hake (Theret)
1040 – 1100	Coffee
1120 – 1230	Implementing change in the North Pacific bottom-trawl groundfish fishery: sweep modifications success (Sethi/Hammond) Successful Nordmore grid implementation in the Gulf of Maine shrimp fishery: external environmental analysis (He) Managing change in the Belgian fishery (Kinds)
1230 – 1400	Lunch
1400 – 1530	Technical measures in the Baltic Sea – an alternative to over-regulation and the brace-and-belt approach (Stepputtis) Case studies (2 groups) Graying fishers Dolly ropes
1530 – 1600	Coffee
1600 – 1715	Case study presentations Group 2: Graying Fishers presentation and discussion (Pol) Group 1: Dolly Ropes presentation and discussion (Zagorski) Wrap up discussion, next steps and future activity, and concluding remarks.

8.6.6.6 Presentation summaries

Adoption of Semi-pelagic Trawl Doors (S. Eayrs)

This talk reviewed an initiative designed to encourage the uptake of semi-pelagic trawl doors and fuel flowmeters. Research testing the doors in the Gulf of Maine had measured a 12% fuel saving and no loss of catch. Fuel flowmeters were known to reduce fuel consumption by around 5%. A loan program with attractive terms and a $ 2,500 rebate to fishers who purchase the doors and meter was made available to fishers, but few took up this opportunity despite many confirming the attractive terms of the program and record high fuel prices.

Overall the Kotter approach was not applied during the initiative described in this case study. No attempt was made to build a sense of urgency other than to remind fishers about high fuel prices and benefits of using the doors. It was assumed fishers would have a sense of urgency. No guiding coalition was formally established and leadership comprised primarily of project promotion by Eayrs and other GMRI staff, with occasional promotion by new makers and the fisher involved in the project. No formal vision was established, or communicated, other than to promote the benefits of the doors and the loan program via industry literature, e-mail, and word of mouth. Through the rebate fishers were incentivized to act and overcome fear; a semi-pelagic door program was also available for approximately 12 months for fishers to test the doors free of charge. Short-term gains including attracting four fishers to take advantage of the program and receive a rebate, although few fishers have purchased these doors thereafter. Long term, few additional fishers have adopted these doors, usually following free testing of the doors, and culture has subsequently not been changed.

Members of the group considered that adoption of changes involved economic rationality, with discounting assessed individually based on perceived future fishing success. That is, fishers may be confident about long-term outcomes, and be more willing to invest resources in beneficial changes, or may be sensing imminent collapse of the fishery, and judge investment as inadequately profitable in the short term.

The relative complexity and utility of semi-pelagic doors were discussed, with different experiences. In Alaska, semi-pelagic doors were rapidly and voluntarily taken up, but it was unclear why this example involved such rapid uptake. In the Adriatic, the doors did not work well, and perhaps were harder to deploy and too complicated to rig and even to be explained. The need to monitor doors with acoustic sensors was mentioned, and while important, many fishers have adopted these doors without using sensors. This is a mixed message that hampers adoption. A struggle getting fishers to change to Dyneema netting was cited as a similar experience where obvious benefits were ignored and change did not occur, despite financial inducements. It was suggested that prioritization by fishers was a root cause for their behavior, tempered by perceptions of complexity and lack of reward, and that timing of proposed change (including resource status) may be an important factor affecting successful adoption. The danger of initial bad experience poisoning any future positive experience was also mentioned.

An important question was raised about the timing of change initiatives, and how or if it is possible to identify the best time to introduce an initiative for maximum effect/uptake. The Kotter model does not explicitly consider timing, but inherently implies the amount of effort required to engender a sense of urgency (the first step of the model) is linked to the timeliness (readiness) of individuals to change.

Technological Change and the Kotter Model: A Case Study with the Raised Footrope Trawl (M. Pol)

The Kotter model represents a possible framework for understanding how change comes about generally. Its application to fisheries has been considered and applied to several case studies. This talk reviewed the history of the development of the raised footrope trawl (RFT), an early example of a successful collaborative gear research program. This gear was implemented as a regulation and was broadly adopted. It continues to be used today. As a successful program, it provided a test case for the applicability and utility of the Kotter model, with some retrospective insight into successful testing and uptake. The impetus for change was the closing of the fishery in 1995, a condition that seems to inspire uptake. The guiding coalition comprised of the Massachusetts Division of Marine Fisheries and members of the fishing industry. The creation of a vision to reopen the fishery required trawl gear to reduce bycatch to

5% of regulated species by volume, although it was not formally articulated as a "vision". Communication involved meeting fleet participants, sharing ideas for new RFT gear designs, and a requirement for self-reporting. Empowerment included allowing fishers to test new gear designs while under permit restrictions, self-reporting of results, and informal tinkering of the RFT to suit individual needs. This combined with flume tank testing and information exchange could be considered as short-term wins. The successful use of this trawl produced additional change through altered boundaries to fishing grounds and ultimately resulted in the new gear being widely accepted. It was concluded that the retrospective application of the Kotter model provides important insight into the process of gear adoption and a possible framework for future actions. It was also noted that despite being unaware of this at the time, that many steps of the Kotter model had inadvertently been applied to a greater or lesser extent.

A technical question on the rigging of the chains in this net was asked.

Conversion of a trawler to a longliner to target blackscabbard and hake (F. Théret)

This presentation described a comparative fishing experiment following the conversion of a trawler to a longliner. It did not link the application of this initiative to the Kotter model primarily because of the comparative nature of the experiment.

One vessel was subsidized for conversion, with the hypothesis that longlining would save fuel, be more efficient, and have no bottom impact. The fishery is a new one, so gear has not been refined or perfected. Catches were not profitable. Crews had different reactions depending on previous experience; many trawl fishers did not like the repetition/boredom associated with longlining. Markets were also new. Improved quality did not result in higher prices to the vessel. Longlining was found to be less efficient than trawling, and it was hoped that with more experience fishing, and refinement of gear, it could become profitable.

It was asked if any plans were being made to encourage additional conversions. It was felt that if the conversion was profitable, no encouragement would be necessary.

Implementing change in the North Pacific bottom-trawl groundfish fishery (S. Sethi, C. Hammond)

This presentation focused on the uptake of trawl sweeps by the North Pacific bottom-trawl groundfish fishery in the Bering Sea and described the process retrospectively against the Kotter model. Alaskan fisheries were urgently seeking reduction of fishing gear impacts in reaction to the need to protect essential fish habitat as required in the Magnuson Stevens Act. eNGOs and other stakeholders were also advocating habitat protections in the area and the fishery. A coalition of a few key individuals was formed that included regulators, scientists, netmakers, conservation engineers, and industry. No single vision was created – the change was reactive and not part of a cohesive vision. A plan to seek funding to test the gear modifications contributed to communication of a vision to reduce habitat impact, driven by the coalition. Field tests citing favorable results and their communication to the Management Council and others helped clear a path leading to the adoption of this gear. Several short-term wins were identified including reduction in bottom contact to essential fish habitat and reduction in unobserved mortality in commercially important crab. Use of the sweep gear was institutionalized by the Council and fishers are using this gear currently; similar work is unfolding in the Gulf of Alaska as a direct result of the success of this program.

The unique characteristics of the Alaskan fishery were cited as reasons for a successful outcome, in response to a question about why change had seemed to unfold quickly and efficiently, compared to s in New England where it is often (seemingly) more challenging. Possible reasons for these differences include: The ownership by large companies encourages a long–term view and investment; skippers work together and are professionalized; personal relationships matter, with trust among captains, gear scientists, and netmakers supporting development and testing. Finally, the relative health of the fish stocks and the profitability of fishers involved in this work were also suggested as a possible explanation for their success.

Successful Nordmøre Grid Implementation in Gulf of Maine Shrimp Fishery: external Environmental Analysis (P. He)

An attempt to analyse the rapid (seemingly "overnight") implementation of the Nordmøre grid in the Gulf of Maine shrimp fishery was presented using a "strategic readiness" model. Assessing a situation from multiple angles and perspectives (political, economic, social, technological, legal, and environmental) identifies the starting place and willingness to change. *Politically*, the shrimp fishery was declining and pressure existed to close the fishery, including from the groundfish fishery which was experiencing declining fish abundance and was concerned over landings of groundfish by shrimp fishers. *Economically*, a fear of loss of revenue from the fishery was balanced by potential loss of marketable fish if bycatch was reduced. Furthermore, an ability to reduce the number of deckhands sorting the catch was viewed by many fishers as an attractive option. *Socially*, the fishery was perceived was viewed negatively as "dirty" by the public. *Technologically*, the grid was successfully tested and implemented in Norway in the 1980s. This development followed a period of approximately 10 years' testing of other bycatch reduction devices, and concerns over hazards of handling a 'hard' grid. *Legally*, NGOs sued NMFS on the persistence of overfishing on groundfish. *Environmentally*, the cod moratorium in Newfoundland created fears of a similar closure in New England, particularly at a time when groundfish abundance was declining (it should be noted that many groundfish fishers also fished for shrimp). Based on this model, the industry seemed prepared and ready for change and rapid uptake of the grid ensued. Mandatory use of this grid occurred within a six-month period, an unusually short period of time, but it remains unclear how or if the circumstances could be applied to other fisheries and realize similar outcomes in a short period.

The strength of regulation was argued to be a major contributory factor affecting the adoption of new gear by fishers, because the playing field was level - all shrimp fishers had to change, not just a few. The threat of lawsuits was cited as another key driver for gear change and adoption. There was general agreement that the big stick approach (or "the hammer"), such as impending regulation or lawsuits provides a strong sense of urgency and extreme incentive to change while economic inducements less so.

Managing change in the Belgian fishery (A. Kinds)

This presentation focused on two projects, although the primary focus was the VALDUVIS project that involved fishers and other stakeholders in a voluntary tool to assess, visualize and monitor the sustainability of the Belgian fishing fleet based on individual fishing data. This project commenced using a multi stage framework that included a scoping phase, followed by an envisioning phase, then experimentation, monitoring, and evaluation phases. Within the scoping phase stakeholder identification, vision development, and problem identification are core components. The envisioning phase comprises of identification of possible sustainability scenarios, followed by development and testing of sustainability indicators (that is, experimentation). Following their introduction to the fishing fleet, the indicators are implemented and their efficacy evaluated. An incentive for fisher involvement in these projects was market access. An outcome of the projects was a multidimensional rosette plot to inform vessel owners and operators, to monitor progress toward sustainability goals based on a suite of identified sustainability criteria, to identify potential policies and research, and to inform buyers.

The Kotter model was used to retrospectively investigate slow uptake by the broader fleet and stakeholder groups. A lack of true urgency was identified as a barrier – a need existed, but the role of stakeholders was unclear, and the overall project was ambitious and unrealistic, with unclear outcomes. Risk of losing market access was real, but was not adequate to develop a sense of urgency by fishers. A successful guiding coalition was built, including a steering group that met several times each year, with five fishers with close ties to the producer organization (responsible for day-to-day management of fisheries, application of Common Fisheries Policy, and communications between policy-makers, researchers, and fishers). They were also kept well informed of all project developments. The project included a visioning stage that was fine-tuned via a cyclic approach over time. Communication among the stakeholders appeared to be adequate and thorough, but the lack of clarity of the vision was again highlighted. Communication included information exchange with fishers and publication in industry literature. Obstacles to change and empowerment were not fully understood, and included resistance and criticism from multiple sources. Short-term gains were unclear and rewards to fishers such as financial gain were perceived to be realized in the long term, so the worth of extra effort was not immediately recognized. A new project to produce additional change is proposed, and it was seen that a greater interaction with fishers to implement the vision was needed, including individuals dedicated to implementing the vision through close relationships and communication with fishers, as well as greater clarity of individual roles. Finally, while new approaches were not institutionalized, progress continues including greater communication of success, and greater focus on step by step implementation. The assessment of fisheries by MSC is considered an option that has changed the dynamics somewhat but raises the question if both systems can coexist.

A comment was raised regarding New Zealand fisheries serving as examples of introducing seemingly rapid change, given their strong centralized government, prevalence of eNGOs, catch value, and quota based management. In response, it was suggested that these fisheries seemed no more adept at changing rapidly than fisheries elsewhere. Further conversation included the importance of considering that change in response to a management action may occur more quickly than change that is voluntary, such as fuel saving options, or environmental impact reduction. Additional discussion centred on measurement of success, and that sometimes success is difficult to measure or appreciate, partly because the vision is poorly articulated upfront or unclear.

Technical measures in the Baltic Sea – an alternative to over-regulation and the brace-and-belt approach (D. Stepputis)

A review of regulations in the Baltic Sea was presented, with examples of what should be maintained, removed, altered, or developed. The chilling effect of overcautious, complex fishery management and unnecessary regulation was emphasized. For example, with the introduction of the discard ban, many gear measures can be removed such as codend regulations, minimum landing sizes, and effort restrictions, otherwise conflict between 'old' and 'new' rules is inevitable. It was argued that the brain power spent on accommodating (and sometimes circumventing) regulations by fishers could be harnessed to facilitate change and solve more important questions if regulations were rationalized and simplified.

8.6.6.7 Case Studies

The topic group participants were divided into two subgroups, and given separate topics to consider using the Kotter Model. The groups were provided with additional material expanding understanding of the model. They devoted approximately one hour to discussion and reported back to the group at large.

Dolly Ropes

The group viewed a video (http://www.dollyropefree.com/) which is an industry attempt to reduce loss of plastic threads from dolly ropes. These ropes serve to protect trawl codends from abrasion on the seabed; however, over time they become worn and strands are often lost at sea. Based on the video, it was felt that a sense of urgency was not established, but instead the video served as a warning to fishers and that they should take steps to avoid loss. A strong guiding coalition was not apparent; some fishers argued for change, but no insight was gained into the expertise and number of fishers involved in the video. It was also not clear if other stakeholders were involved. The vision was established, and it was simple and straightforward: to reduce loss of dolly ropes. Communication was achieved thru the video but it was not clear if other communication was attempted, what results were expected, how they would be collected, and where they would be used. Empowerment was seemingly modest, simply limited to a plea for others to join their efforts. A clear message was required, including why others should participate. Short-term wins were absent from the video. They could have promoted dolly rope free activity, perhaps even considered dolly rope free certification. Encouragement of new designs to replace dolly ropes was weak, and no milestones or time frames for success were obvious. Consolidation of improvements was absent, and no cultural change, or institutionalized changes was apparent. They could have also expanded to all plastics dumped at sea.

It was suggested that the Kotter model provided an interesting and fresh way to look at a problem or issue in fisheries, a problem that is important to tackle appropriately, and that the model highlighted certain deficiencies in their approach which might otherwise be missed and might contribute to their success or lack thereof. It was also suggested the video may have been seeking additional involvement and was not designed to provide a fuller perspective. The intended audience was not entirely clear, facilitated by seemingly conflicting messages and statistics that were unclear.

Ageing of the Fleet

The group was asked to develop a plan of action following the Kotter Model to address the problem of an aging fishing fleet. This problem had been identified as occurring across the USA including Alaska, as well as other countries.

The group recognized the problem but quickly identified that to deal with it a clear vision was necessary. They noted that 'a vague statement but good intentions' is not an ideal starting point to deal with an issue, but that a clear vision was essential. They then realized the problem is not just about the fleet getting old, but maintaining of the economic health of a fishery, as a fleet dominated by older fishers risked under exploitation of the resource if they were not replaced. The "true" problem was therefore interpreted to be barriers to entry by young people, heavily influenced by the health of the resource – few new fishers when fishery health is poor, costs of quota, vessels and licenses, perceived status associated with employment as a fisher, perception that fishing is hard work, and pay is poor, lack of training, and complex fishery regulations. The importance of understanding the vision was considered when identifying a sense of urgency, although the possibility of creating a false sense of urgency based on emotional reaction to the problem was considered. A vision was presented and discussed:

- An economically stable and sustainable fishery (as well as the knowledge base to exploit it) and a robust age structure in the fleet by increasing accessibility for younger people to enter the fishery.

An alternative was provided and discussed, based on the notion that a vision should be sharp and concise:

- Increasing accessibility for younger people to enter the fishery.

To build a coalition, older fishers mentors, young successful fishers, and financing experts were identified. The need to attract younger people to training and courses via updated curricula and content was discussed. Additional Kotter steps could not be addressed in the provided time.

8.6.6.8 Discussion

The group were provided an opportunity to provide final thoughts or discussion points. One participant spoke of a colleague that is applying a so-called Pre-mortem approach ("project has died before it has started") whereby he envisions the project has gone wrong, then envisions why it might have gone wrong, and then creates a plan in place to take remedial action. This was suggested worthy of further consideration by group members.

A so-called 'super' model was presented by Eayrs to guide discussion about possible next steps. The model combines Kotter (with its focus on process and inertia), and other models that consider the constructs of change readiness and time, which are not clearly apparent in the Kotter model. Change readiness was posited as a possible future direction for the group, and through questionnaires it is possible to evaluate cognitive and affective change readiness. This gets to important constructs such as discrepancy, appropriateness, efficacy (that a way can be found to solve the problem), support (is it available and adequate?), and valence (that it relates to them).

The group discussed how much further we could go given our limited expertise in human behaviour and a need was mooted to invite social scientists to contribute to the group. Is a workshop between this group and a social science ICES expert group a possible forward step? Should we reach out to the ICES human dimensions group or other group? Can models of human behaviour help guide options to facilitate change? Concerns were also raised that the meeting next year in New Zealand would limit continuity of the group and hamper achievement of planned Topic Group outcomes due to the expense and time of travel to a remote location.

Additional discussion centred on a need to search for case studies to identify/categorize why change was successful or otherwise, and to use this outcome to help inform future change initiatives. Such an approach could be small or large-scale and would also help identify key attributes for success that could be the target of future efforts, and which would further help validate the efficacy of the Kotter model in a fishing industry context.

8.7 Recommendations

1. The group will work intersessionally to recruit a social scientist with experience in fishing gear/collaborative research, possibly from New Zealand or nearby the meeting location. Input from a social scientist will help validation and support our understanding of human decision-making and to meet the third term of reference.
2. We will inform ICES Strategic Initiative on the Human Dimension (SIHD) of findings of the topic group and seek opportunity for further collaboration.
3. A retrospective review/manuscript of prior successful and unsuccessful studies via literature and personal experiences, with respect to change models, would be useful for members of WGFTFB, and may be completed by members of the TG. It would help describe what seems to work and what seems to not work
4. The conveners and others will reach out to social scientists, alert them of our progress and need, build bridges, complete our TOR next year and then concentrate on working closely with other groups to help address outstanding TORs. If a social scientist is recruited, the group will meet in 2017 and fulfill the remaining terms of reference. If not, then we will prepare a final report in the intersession.

9 Topic Group: Evaluation of trawl groundgear for efficiency, bycatch and impact on the seabed (Groundgear)

9.1 Introduction

A WGFTFB topic group convened by Pingguo He with remote supports from co-chairs Roger Larsen (Norway) and Antonello Sala (Italy) was formed and met on 3–7 April 2017 in Nelson, New Zealand to discuss and summarize status and progress and knowledge of designs of groundgear and other components dragged along the seabed during bottom trawling. The topic group was to evaluate current and past work regarding to their efficiency for target and bycatch species, effect on the seabed, and energy use. This topic group examines past, current and future studies from a wide range of scientific fields, such as hydrodynamics, drag and gear design, strategies and technology enhancing reduced fuel consumption and reduction in gas emissions, selectivity and behaviour on fish, shrimp and crab.

Terms of reference were:

- Describing and summarizing current and past work in relation to seabed contact/impact of various types of bottom-trawl groundgear
- Discussing and describing possible methods to reduce unnecessary bottom contact and fuel use due to the groundgear
- Discussing and summarizing the effect of trawl groundgear on the efficiency and selectivity for target and bycatch species
- Making recommendations on future experimental and theoretical work to understand and improve the function of groundgear of bottom trawls
- Making recommendations on the "best practice" regarding the design and operation of bottom trawls with less effect on ecosystem and emission

Justification:

With uncertainties around the use of groundgear in bottom trawling and its impact on bottom fauna, it is important to review the current status of the design and use of groundgear in various fisheries and to propose new investigations that will contribute to more environmentally-friendly fishing gears. Continuous contact between gear and seabed during bottom trawling is believed to be of importance for efficient harvesting in many groundfish fisheries, but in some bottom trawls, total weight of the trawl may be out of proportions for the purpose. High fuel consumption in trawl fisheries is often associated with heavy groundgear being dragged along the seabed. Recent research and practices in the North Pacific and Northwest Atlantic bottom-trawl fisheries indicate that ground-contacting components including groundgear can be modified with no or little impact on the catch of target species. In the Northeast Atlantic, bottom trawling is often performed in areas of important fisheries for king crab and the rapid growing snow crab fishery, with unknown impact on these crab stocks. As crab fisheries increase in intensity, more gears will be damaged and lost due to collisions between trawl and pot fisheries. Alternative and lighter groundgears have been tested, but it is unclear if they are efficient for retaining target species and not increasing the catch of unwanted bycatch compared to conventional configurations. Discussion and summary of current knowledge and possible future development of bottom-trawl gear or its alternatives for harvesting traditional groundfish species.

9.2 Participants

The Topic Group met on 6 April 2017 with the following participants (listed in a random order). Chairs Roger Larsen and Antonello Sala were not able to participant the meeting in person, but provided remote support to the Topic Group.

Pingguo He (Chair)	University of Massachusetts Dartmouth	USA
Noëlle Yochum	NOAA Alaska Fisheries Science Center	USA
Brianna King	Alaska Pacific University	USA
Aileen Nimick	Alaska Pacific University Fisheries	USA
Josh Cahill	Australian Fisheries Management Authority	Australia
Liuxiong Xu	Shanghai Ocean University	China
Ludvig Ahm Krag	DTU Aqua, Danish Technical University	Denmark
Petri Suuronen	FAO Fisheries and Aquaculture	Italy
Craig S. Rose	FishNext Research	USA
Darcie E. Hunt	IMAS	Australia
Haraldur Einarsson	Marine and Freshwater Research Institute	Iceland
Paul Winger	Memorial University of Newfoundland	Canada
Tomas Schmidt	Memorial University of Newfoundland	Canada
Mark Lomeli	Pacific States Marine Fisheries Commission	USA
Chun Woo Lee	Pukyong National University	Korea
Liming Song	Shanghai Ocean University	China
Jure Brčić	University of Split	Croatia
Pieke Molenaar	Wageningen Marine Research	Netherlands
Steve Kennelly	IC Independent Consulting	Australia
Paul Freeman	Hampidjan NZ	New Zealand
Carolyn Collier	Hampidjan NZ	New Zealand
Valentina Melli	DTU Aqua, Danish Technical University	Denmark
Hyun Young Kim	National Institute of Fisheries Research	Korea

9.3 The accomplishment

The Topic Group defined the type of fishing gear that this group will focus – the bottom trawl as defined in the FAO classification of fishing gears. It will thus include beam trawls, otter trawls, pair trawls, Nephrops trawls, shrimp trawls, and other unspecified bottom trawls. However, other bottom-tendering gears such as dredges will not be included in the Topic Group's work.

The Topic Group defined "groundgear". The "groundgear" in this topic group (and its report) refers all components of a trawl that typically contact the seabed during fishing process, including, but not limited to:

- Groundrope, and tickler chains
- Sweeps and lower bridles
- Trawl doors
- Center weight of twin/triple rigs
- Shoe/head of a beam trawl

The example of "groundgear" in a typical bottom trawl is shown (in red) in Figure 9.3.1.

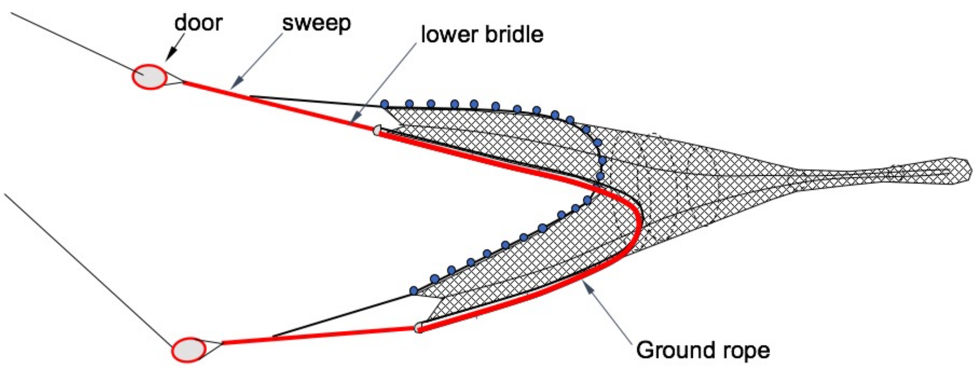

Figure 9.3.1. A typical bottom trawl with the 'groundgear' highlighted in red.

The Topic Group defined scope of this topic group, and reaffirmed the Term of References of this TG:

- Seabed contact and impact of groundgear;
- Fuel consumption and emission reduction regarding the groundgear;
- Selectivity and bycatch characteristics of groundgear.

The Topic Group will identify gaps of knowledge and technology and recommend future research directions related to groundgear of a bottom trawl. From the knowledge gathered, we will attempt to recommend "best practice" on the design of groundgear of bottom trawls with regard to minimal seabed impact, low fuel consumption and emission, high capture efficiency for target species, and best possible reduction of bycatch.

The Topic Group heard seven presentations related to the topic:

- Aileen Nimick: Fishing effects in 3D – it's not all about bottom contact anymore;
- Roger Larsen (presented by Pingguo He): Groundgear and trawl systems used in the Northeast Atlantic;
- Paul Winger: Comparative fishing to evaluate the viability of an aligned footgear designed to reduce seabed contact in Northern shrimp bottom-trawl fisheries;
- Craig Rose: Groundgear and crab mortality in Alaska trawl fishery;
- Mark Lomeli: Use of lights on the footrope of a shrimp trawl for pink shrimp to reduce;
- Steve Kennelly: Groundgear modifications in Australian river shrimp trawls;
- Pingguo He: Examples of groundgear in use in New England.

9.4 The Work Plan

Members will work during the inter session and to provide a summary of various types of groundgear in use in respective bottom-trawl fisheries. This will be used to compile a list of groundgear in bottom-trawl fisheries around the world. FAO representative will contact South American and Southeast Asian country colleagues to provide groundgear information in these regions. Topic Group members will work during the inter session to provide relevant information related to the ToR and to report at the 2018 WGFTFB meeting. The Topic Group will meet in person at the 2018 WGFTFB meeting in Bergen, Norway. It was also suggested that the "groundgear" may be considered as a Mini-symposium topic during the 2019 FAO-sponsored WGFTFB meeting.

Over the "Groundgear" TG lifetime, the group will:

- Compile a catalog of "groundgear" used in different parts of the ocean (North Sea, Baltic Sea, Mediterranean, Northeast Atlantic, Northwest Atlantic, Northeast Pacific, Northwest Pacific, Oceania, and others)
- Review and synthesize literature to provide the state-of-art account on the subject
- Identify gaps in knowledge and potential areas of further development/research
- Produce a final report to the WGFTFB in 2019.
- Possible publication of the report (or part of it) in FAO Fisheries Report or in a peer-reviewed journal

10 Topic group: Assessment on energy use and fuel consumption in fisheries (Energy)

Conveners: Emilio Notti (Italy) and Steve Eayrs (USA)

10.1 Introduction

The purpose of this topic group (TG) was to complete a preliminary review of energy audits and recent efforts to reduce fuel consumption in commercial fisheries. It also served to explore the potential to develop standard energy audit protocols and methodology, including standardized performance nomenclature, with a view of providing guidance for future efforts to audit fishing vessels and conserve fuel consumption. Individuals with experience in energy audits and fuel saving options in fisheries, including hydrodynamic otter boards and reduced drag trawls, were invited to present their experiences to the group.

10.2 General Overview

The TG met on Thursday 6 April. Only five people participated in this meeting, representing 4 countries. Consideration was given to postponing the meeting until next year, in the hope of increasing the number of participants with interest in energy audits, but with few other WGFTFB members known to have conducted energy audits it was decided to continue with the meeting. Unfortunately, one convener (Eayrs) was only present for the first hour before departing to participate in the change management topic group.

10.3 Terms of Reference

The terms of reference for this TG were:

i) Identification of energy audit testing protocols and performance metrics by country, fisheries, fleet sector, etc., including monitoring of GHG emissions

ii) Evaluation of the potential to harmonize audit protocols for information collection of energy use in different fisheries

iii) Definition of performance metrics e.g. litre per hour; litres per kilogramme of catch, litre of fuel consumed per nautical mile etc., and identify and discuss equipment and tools to evaluate performance

iv) Design of a general dataset for data and information collected, open data

10.4 List of Participants

Name		Institution	E-mail
Emilio	Notti	ISMAR, Italy	e.notti@an.ismar.cnr.it
Steve	Eayrs	Gulf of Maine Research Institute, USA	steve@gmri.org
John	Wakeford	MG Kailis Group, Australia	johnwakeford@kailis.com.au
Heui Chun	An	National Institute of Fisheries Science, Rep. of Korea	anhc1@korea.kr
Hyun Young	Kim	National Institute of Fisheries Science, Rep. of Korea	sys9318@korea.kr
Yoshiki	Matsushita	Nagasaki University	yoshiki@nagasaki-u.ac.jp

10.5 Discussion

The findings of the TG are described in the context of the four terms of reference.

i) Identification of energy audit testing protocols and performance metrics by country, fisheries, fleet sector, etc., including monitoring of GHG emissions

A presentation by Eayrs described the methodology applied to audit boats in two fisheries, the New England groundfish fisheries in the USA (Eayrs, 2012) and the shrimp fishery in Thailand (Eayrs, in prep.). In both instances the methodology loosely followed that outlined in Wakeford, (2010), commencing with an interview of trawler captains to understand how they operate the boat during a typical fishing trip, including steaming and fishing times, duration, and vessel speed, to estimate fuel consumption during each operational phase during a typical trip, and to understand outputs including landed catch and operational expenses. The next phase of the audit included a site visit to identify and view sources of fuel consumption, measure important vessel specifications, and refine initial estimates of fuel saving options. The final phase would normally include detailed analysis of energy use, savings, and associated costs, the introduction of fuel saving options, and their measurement and evaluation, however, in both fisheries no new fuel saving options were introduced during the period of each project.

Wakeford provided an oral report of his knowledge and experience conducting energy audits in shrimp trawl fisheries in Australia. This information is summarized in Wakeford, 2010. Wakeford described how energy audits are an effective way to understand how energy is used in a fishing operation, and to identify options to reduce energy consumption and associated costs. A methodology based on a three-level audit tool was presented and discussed, based on AUS/NZ Energy Audit Standard 3598:2000. The following is a summary of the audit tool:

Level 1 audit

A Level 1 audit allows the overall energy consumption of a fishing vessel to be evaluated. This provides an initial benchmark so the effect of future energy-saving measures can be tracked and evaluated. This audit may be a desktop study, but only provides a very approximate evaluation of savings and costs. Audit accuracy is generally around ±40%.

Level 2 audit

A Level 2 audit usually involves a visit to the fishing vessel to refine initial evaluation of sources of energy, energy consumed, and what the energy is used for. It also identifies potential areas where savings may be made, recommends a suite of fuel saving options, and provides a statement of costs and potential savings. Audit accuracy is generally around ±20%.

Level 3 audit

A Level 3 audit provides a detailed analysis of energy consumption and savings, and predicted cost of fuel saving options. The auditor may need to metering and logging equipment on the vessel for a period of time. The report from this audit can be used to justify significant investment by the vessel owner. Detailed economic analysis is required. Accuracy of figures would be within +10% for costs and -10% for benefits.

Notti then described an approach he has used in European fisheries. This approach is based heavily on protocols and metrics reported by Sala *et al.* (2011) and described by Buglioni *et al.* (2012) that considers the vessel to be an 'energy system' with energy inputs and outputs to be assessed to evaluate energy performance (Figure 10.5.1). A preliminary survey of the vessel is carried out to collect technical specifications of the boat and to identify various vessel activities during a fishing trip. Depending on the specific activity of the vessel, different energy users (machinery plants) may be installed and utilized, and they may be categorized as mechanical, electric, and hydraulic depending on their source of energy consumption. The propulsion system, typically represents the main source of energy consumption, especially for trawlers, and for vessels that are required to refrigerate large amount of fish, or provide significant illumination, electricity can be a significant source of energy consumption.

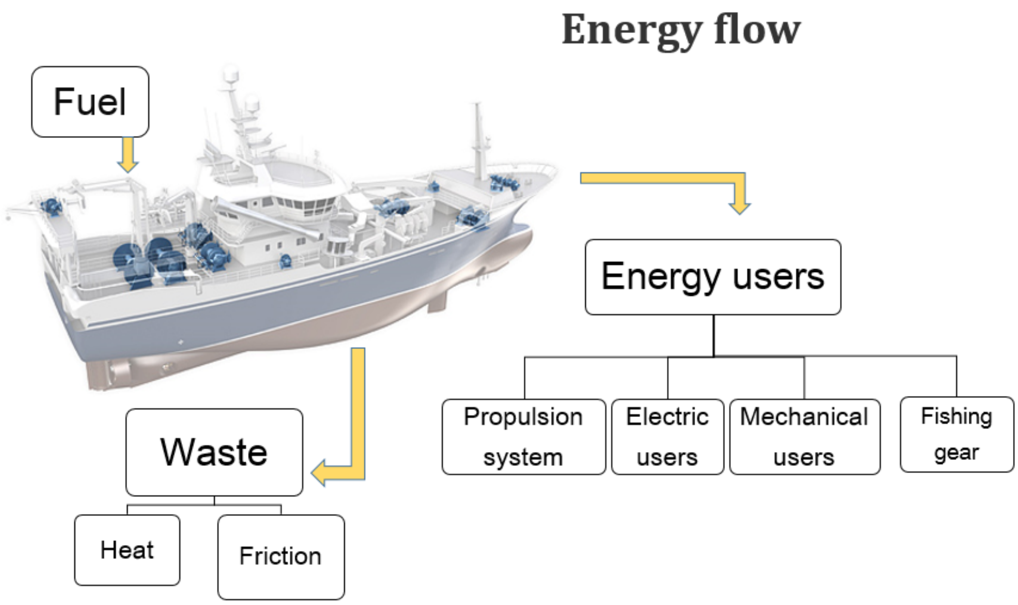

Figure 10.5.1. Energy flow of a fishing vessel. The energy input is represented by fuel burned. The energy is adopted by number of users (machinery plants), depending on the architecture and the specific activity of the vessel. Part of the energy is wasted through exhaust gases and other minor losses such as cooling systems and frictions.

Notti then described the importance of clearly defined measures and indicators. An energy consumption indicator (ECI) representing the amount of energy required by a specific energy plant (i) is defined by the standardization of energy consumed for the total power installed (P),

$$ECI = \sum_i ECI_i = \sum_i \frac{E_i}{P}$$

The overall standardized energy consumed can be identified by summing all the energy indicators. In order to evaluate the overall energy efficiency of the vessel it is necessary to define also an indicator which accounts for the fuel burned. The fuel consumption indicator (FCI) is defined by the fuel consumption (F_C) standardized by the total power installed (P),

$$FCI = \frac{F_C}{P}$$

The group also had a wide-ranging conversation related to this TOR. Key points were:

- It is not always possible to measure all sources of energy consumption, but major sources should be identified and measured in an energy audit.
- Several common aspects of an energy audit were identified between participants, including a need to conduct a preliminary evaluation of the fishing vessel, including technical specifications of hull and machinery, identification of dominant activities (e.g. trawling, steaming, etc.), timing and duration of each dominant activity, and their respective measurement of fuel consumption. This will provide insight into total energy demand by the vessel, when and how energy is used, help prioritize where energy conservation efforts are necessary, and allow first-order comparison between vessels.
- The standardization of energy demand and consumption allows comparison between vessels or between the same vessel.
- Accurate assessment of energy consumption and performance between plants is necessary to estimate economic performance of the vessel. It also is useful to evaluate the impact of potential modernization or improvements (see Notti *et al.*, 2014a; 2014b for examples) through cost–benefit analysis.
- The group discussed the importance of estimating or measuring GHG emissions and reporting emissions level as part of an energy audit. A number of references were discussed dealing with the estimation of GHG emissions by measurement of the fuel consumption, including the Greenhouse Gas Protocol (see http://www.ghgprotocol.org/Third-Party-Databases/IPCC-Emissions-Factor-Database for details). The group agreed that an estimation of GHG emissions during all key phases of a fishing trip, e.g. fishing, steaming, etc. should be reported together with technical information of energy consumption in an audit report.

ii) Evaluation of the potential to harmonize audit protocols for information collection of energy use in different fisheries

A number of different approaches for energy audits were presented and discussed by the TG, and to compare results obtained by these approaches the need for a standardized approach applied to future audits was discussed.

The TG eventually concluded however that it was not necessary to strictly apply a standardized approach as long as a common general approach is maintained (e.g. Gabiña *et al.*, 2016), despite the inherent attractiveness in doing so. In part, this is because comparison between vessels serves limited purpose given the number and magnitude of variables that influence energy performance, even between identical vessels, including variation in operational practice by captains, extent of hull fouling, and variation in loading. Nevertheless, it was recognized that efforts to apply a standardized approach may permit limited merging of audit outcomes, i.e. by country, type of vessel, fishery, particularly if energy consumption data are referenced to a particular vessel activity and/or relative to other measurement metric such as time or volume of catch.

The TG considered it important to highlight the need for any audit to report main recommendations, based on the observed level of energy consumption and efficiency, to provide guidance for future developments and energy saving.

iii) Definition of performance metrics e.g. litre per hour; litres per kilogramme of catch, litre of fuel consumed per nautical mile etc., and identify and discuss equipment and tools to evaluate performance

It was agreed that measuring only fuel consumption, or changes in fuel consumption, was inadequate because it did not permit a sufficiently detailed assessment of fuel consumption and was of limited use to fishers and others. Improved performance metrics were suggested, specifically those that compare fuel consumption relative to an output of vessel activity, such duration of fishing activity, weight of landed catch, or value of landed catch.

It was also suggested that consideration be given to estimating the energy return on investment (EROI) of a fishing operation. This metric calculates the ratio between the protein energy in the landed catch and the energy in the fuel used to land the catch, and it can be evaluated over any period or unit of fishing operation e.g. per haul, or pot lift. This metric can be used to highlight the relative performance of different gear types, or between fishing activity and other sources of protein such as beef, pork, and chicken.

There was limited discussion about equipment and tools to evaluate energy performance (in part because of limited available time), although it was clear that many fishing vessels do not have a fuel meter, which the group considers a vital piece of equipment to raise awareness and foster efforts to conserve fuel. The equipment used in the Thai energy audits was recognized as a low-cost option for recording energy audit data that was easily transferable between vessels, although it does require considerable post-trip data processing (Figure 10.5.2).

iv) Design of a general dataset for data and information collected, open data

There was limited discussion about need to develop an open source repository of fishing vessel data with a specific focus on energy consumption and conservation. The potential application of this repository was discussed as well as the challenges of collecting relevant data. The achievement of this repository requires a standardized data collection survey and data sheet (form). The collection of this preliminary information has two main effects:

- it is possible to complete a brief evaluation of energy use; because of this kind of approach the accuracy of the evaluation is expected to be high, but the benefit comes from some important initial feedback for an eventual deeper analysis;
- the form could be provided with a grid to identify the main important energy users (plant) and thus being able to set up a suitable monitoring tool and approach.

The challenges of collecting this information and its utility were discussed, including concerns by fishers about making these data publicly available. Nevertheless, it was suggested it is quite possible to handle such data properly while maintaining a proper level of confidentiality.

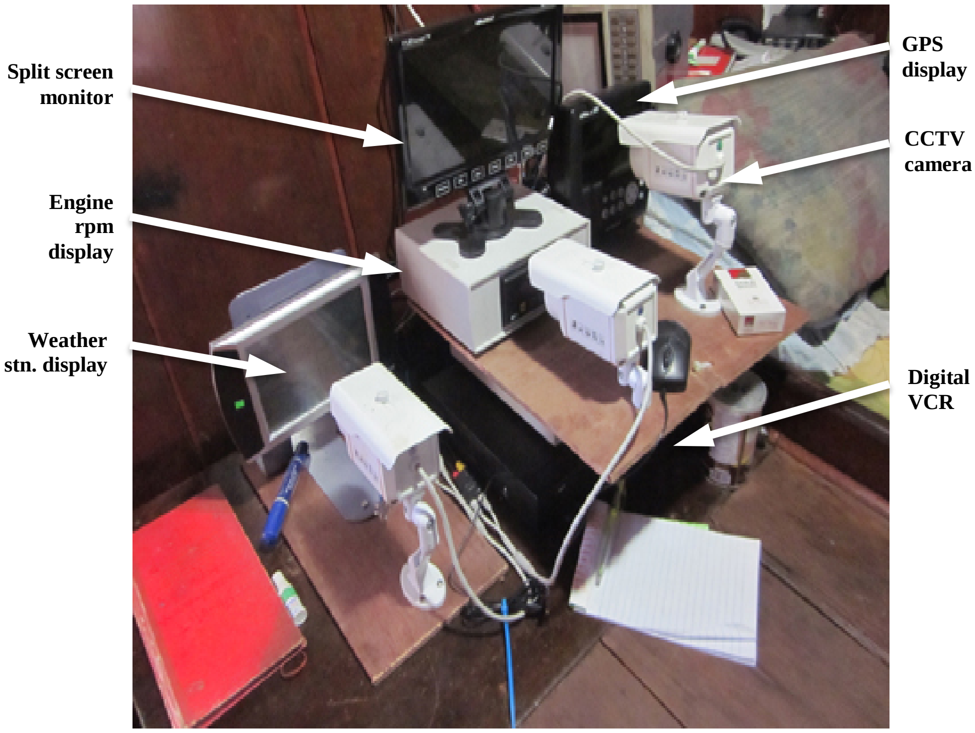

Figure 10.5.2. Energy audit equipment used in the Thai energy audit project.

10.6 Recommendations

The TG made the following recommendations:

i) Greater efforts are required to raise awareness of the need to conserve fuel and greenhouse gas emissions in the fishing industry. This includes promoting the application of energy audit protocols and potential benefits from audit outcomes to all fishers;

ii) Widespread promotion of fuel flowmeters is necessary. These meters are relatively cheap, can encourage behavioural change and save significant amounts of fuel, and they serve to encourage consideration of additional fuel saving options;

iii) For a more detailed energy profile of a single vessel it is necessary to include evaluation of energy demand by main users (plants);

iv) The application of the Australian approach to energy audits should be considered as it provides a systematic, thorough way to consider and apply an energy audit;

v) The metering system applied in Thailand seems cost-effective for developing countries, despite significant post-trip evaluation of video footage;

vi) EROI should be actively promoted as a performance metric, particularly as it can highlight the superior efficiency of fishing activity compared to other sources of animal protein;

vii) Energy audits should include an overall assessment of the potential GHG emission reduction that can be quantified either by measuring GHG emissions directly onboard or by estimation according to international standards.

10.7 References

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11 National Reports

11.1 General Overview

Participants were asked prior to the meeting to prepare summaries of current and expected research related to the activities of the WG within their country. Thirteen National reports were received: Belgium, France, Germany, Spain, Japan, Italy, United States, Denmark, Sweden, Ireland, Netherlands, Iceland, Scotland, Norway, and Canada.

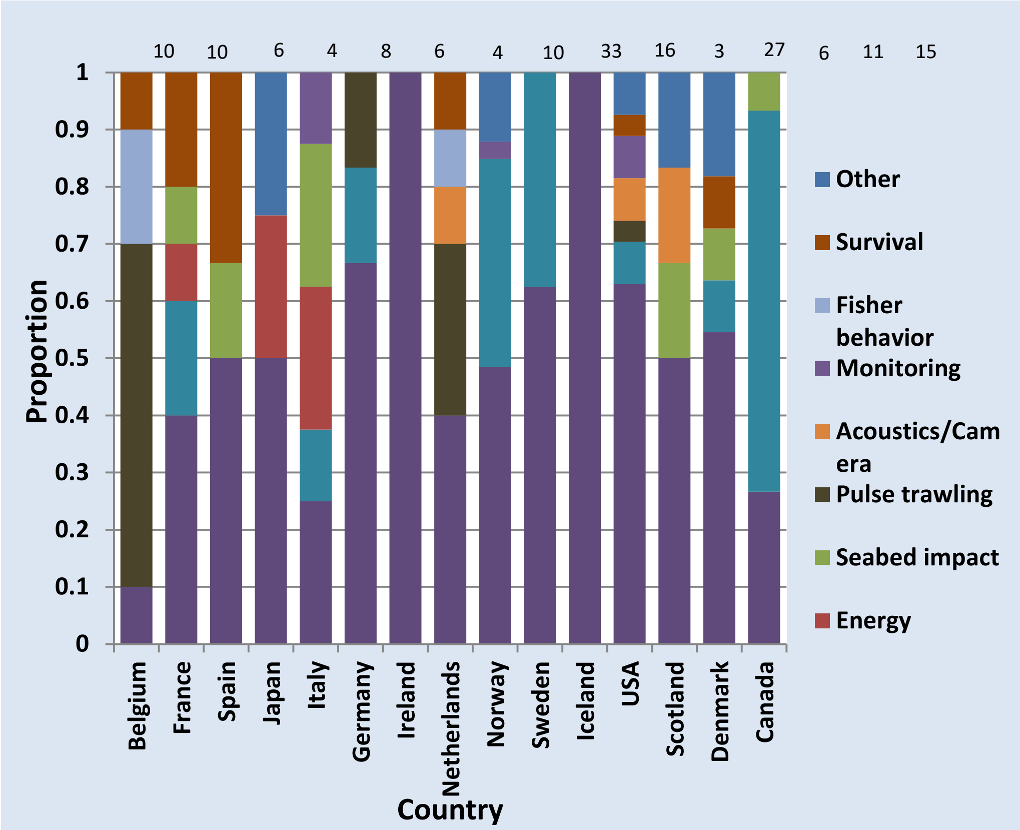
The full text of these reports is inserted below, by country. A summary of some of the major themes across nations was prepared during the meeting. A word cloud was produced from the full text of each National Report as a means of illustrating the main areas of interest in each reporting country. A word cloud displays words in font sizes proportional to their frequency within the text. The most common three words from each country are listed in descending order in the table below. Not surprisingly, words such as “codend”, “trawl”, “trap”, “fishing”, and “fish” were common.

To provide a brief overview of the research being carried out each project described in the National reports was classified by theme (Figure below). Projects related to fishing gear selectivity were the most dominant across all countries combined, representing 49% of all reported projects, with every country reporting at least one selectivity study. Pulse trawling dominated research in Belgium (60% of all reported projects) but was also reported in the Netherlands (30%), Germany (17%), and the USA (4%). Catching efficiency projects were reported in Canada, (67%), Sweden, (38%), Norway (36%), France (20%), Germany (17%), Italy, (13%), Denmark (9%), and the USA (7%). Many countries were also engaged in survival studies, including Belgium, France, Spain, Netherlands, USA, and Denmark, and seabed impact, including France, Spain, Italy, Scotland, Denmark, and Canada. Only France, Japan, and Italy reported energy conservation projects.

The contents of the individual national reports were NOT discussed by the group, and as such they do not necessarily reflect the views of the WGFTFB.

Summary of word cloud by country, based on National Reports. Only the most frequent three words are indicated, in descending order from left to right, to provide insight into the research focus of each country.

Country	Words	Country	Words
Iceland	Mesh, catches, codend	Germany	Fishing, cod, trawl
Belgium	Pulse, shrimp, fishing	Ireland	Codend, trawl, grid
France	Fish, survival, species	Netherlands	Pulse, fish, catch
Spain	Species, survival,	Norway	Fish, catch, trawl
Japan	Catch, beam, fishing	USA	Trawl, bycatch, halibut
Italy	Fishing, data, species	Scotland	Codend, four-panel,
Sweden	Fishery, cod, trap	Denmark	Gear, selectivity, fisheries
Canada	Trawl, bottom, project		



The proportion of projects by major category, as determined from each National Report. The number of projects reported in each report is also provided.

11.2 Belgium

11.2.1 Institute for Agricultural and Fisheries Research (ILVO) – Fisheries and Aquatic Production, Technical Fisheries Research Group

Arne Kinds (report compiler), Maarten Soetaert, Heleen Lenoir, Bart Verschueren

Pulse trawling: Evaluating its impact on prey detection by small-spotted catshark (*Scyliorhinus canicula*)

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Pulse fishing may pose a promising alternative for diminishing the ecosystem effects of beam trawling. However, concerns about the impact on both target and non-target species still remain, among others the possible damage to the electro-receptor organs, the Ampullae of Lorenzini, of elasmobranchs. The current study aimed to examine the role of pulsed direct current (PDC) used in pulse trawls on the electro-detection ability of the small spotted catshark, Scyliorhinus canicula. The electro response of the sharks to an artificially created prey-simulating electrical field was tested before and after exposure to the pulsed electrical field used to catch flatfish and shrimp. No statistically significant differences were noted between control and exposed animals, both with the number of sharks exhibiting an electro response prior to and following exposure as well as regarding the timing between onset of searching behaviour and biting at the prey simulating dipole. These results indicate that, under the laboratory circumstances as adopted in this study, the small-spotted catshark are still able to detect the bioelectrical field of a prey following exposure to PDC used in pulse trawls. However, to fully grasp the impact of PDC on elasmobranchs, further studies are imperative, including examining the effect on reproduction and young life stages, the longer term and indirect influences and experiments under field conditions.

Side-effects of electrotrawling: Exploring the safe operating space for Dover sole (*Solea solea* L.) and Atlantic cod (*Gadus morhua* L.)

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Electrotrawling is currently the most promising alternative for conventional beam trawls targeting soleand shrimp, meeting both the fisher's aspirations and the need for more environmentally friendly fishing techniques. Before electrotrawling can be further developed and implemented on a wider scale, more information is needed about the effects of electrical pulses on marine organisms. Adult Dover sole (*Solea solea* L.) and Atlantic cod (*Gadus morhua* L.) were used in the present study as model species for flatfish and roundfish, respectively. These animals were exposed to homogeneously distributed electrical fields with varying values of the following parameters: frequency (5–200 Hz), electrical field strength (100–200 V/m), pulse polarity, pulse shape, pulse duration (0.25–1 ms) and exposure time (1–5 s). The goal was to determine the range of pulse parameters which can be regarded as safe and thereby also to evaluate the effect of the pulses already being used in commercial electrotrawls. Fish behaviour during and shortly after exposure, 14-days post exposure mortality rates, as well as gross and histological examination were used to evaluate possible effects. During exposure, both species showed an escaperesponse below a frequency of 20 Hz and a cramp reaction above 40 Hz. These reactions were immediately followed by post-exposure escape behaviour and at high electrical loads cod showed tonic-clonic epileptiform seizures. No mortality was observed and histological examination did not reveal any abnormalities, except for one cod showing a spinal injury. These data reveal the absence of irreversible lesions in sole as a direct consequence of exposure to electric pulses administered in the laboratory, while in cod, more research is needed to assess cod's vulnerability for spinal injuries when exposed to the cramp pulses.

Laboratory study on the impact of repetitive electrical and mechanical stimulation on Brown Shrimp (*Crangon crangon* L.).

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Pulse trawling is currently the best available alternative to beam trawling in the Brown Shrimp (*Crangon crangon* L.) and Dover Sole (*Solea solea* L.) fisheries. To evaluate the effect of repetitive exposure to electrical fields, Brown Shrimp were exposed 20 times in 4 days to commercial electrodes and pulse settings used to catch Brown Shrimp (shrimp startle pulse) or Dover Sole (sole cramp pulse) and monitored up to 14 days post first exposure. The survival, egg loss, moulting and the degree of intranuclear bacilliform virus (IBV) infection were evaluated and compared to stressed but not-electrically-exposed (procedural control) and non-stressed non-exposed (control) Brown Shrimp as well as to Brown Shrimp exposed to mechanical stimuli. The lowest survival at 14 days post first exposure was observed for the sole cramp pulse treatment (57.3%), which was significantly lower than the procedural control group with the highest survival (70.3%). No effect of electrical stimulation on the severity of IBV infection was found. The lowest percentage of moults was observed for the repetitive mechanical stimulation treatment (14.0%) which was significantly lower than the procedural control group with the highest percentage of moults (21.7%). Additionally, the mechanically stimulated Brown Shrimp that died during the experiment had a significantly larger size compared to the surviving individuals. Finally, no effect of the shrimp startle pulse was found. Therefore, it can be concluded that repetitive exposure to a cramp stimulus and mechanical stimulation may have both have negative effect on the growth and/or survival of Brown Shrimp. However, there is no evidence that electrical stimulation of electrotrawls would have a larger negative impact on Brown Shrimp stocks than mechanical stimulation of conventional beam trawling.

Atlantic cod show a highly variable sensitivity to electric-induced spinal injuries.

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Pulse trawling is the most promising alternative to conventional beam trawls targeting sole *Solea solea*, but due to the electric fields created by electrotrawls, spinal injuries are reported in gadoid round fish such as Atlantic Cod *Gadus morhua*. This study aimed to investigate variability of the occurrence of electric-induced spinal injuries in Cod. Four groups of Cod, each originating in different wild or farmed stocks, were exposed similarly to pulses used by electrotrawls targeting sole. Effects were analysed based on behavior, mortality and lesions up to 14 days after exposure and morphological characteristics such as size, somatic weight, muscularity, number of vertebral bodies and vertebral mineral contents of animals were compared among different cohorts. Second, the influence of parameters such as water temperature, electrode diameter, pulse type and amplitude were tested. Electrode diameter and pulse amplitude showed a positive correlation with the intensity of the fish's reaction. However, the present experiments confirmed that Cod also show a variable vulnerability, with an injury rate varying between 0 and 70% after an (almost) identical exposure near the electrode. This indicates that these injuries are not only determined by the pulse parameter settings, but also by subtle fish-specific parameters. Although the absence of a sensitive group of Cod did not allow the elucidation of the conclusive parameter, the effect of physiological as morphological parameters such as intervertebral ligaments and rearing conditions during early life merit further attention in future research.

Reducing bycatch in beam trawls and electrotrawls with (electrified) benthos release panels

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Benthos release panels (BRPs) are known for their capacity to release large amounts of unwanted benthos and debris, which can decrease mortality on these animals and eases the on board sorting process aboard demersal beam trawlers. They can reduce the bycatch of undersized fish, which is desired once the European discard ban is implemented. However, unacceptable commercial losses of sole (*Solea solea* L.) and damage to the BRP as a consequence of suboptimal and unsuitable rigging in the traditional beam trawl with chain mat, is hampering a successful introduction in commercial beam trawl fisheries. To eliminate these drawbacks, square-meshed BRPs with different mesh sizes (150, 200, and 240 mm) were rigged in a trawl with square net design as used in electrotrawls and tested for selectivity. In addition to this, the effect of electric stimulation at the height of the BRP to eliminate the loss of commercial sole was examined. According to our observations, no abrasion of the net attributable to suboptimal rigging occurred in any of the BRPs tested. The catch comparisons showed significant release of benthos and undersized fish in all panel mesh sizes, but there was always a significant loss of marketable sole in the 150, 200, and 240mm BRPs. Adding a 80 Hz electric cramp stimulus to the BRP, resulted in equal catches of sole larger than 25 cm as the standard net, without negatively affecting the release of benthos and most undersized commercial fish. This clearly demonstrates the promising potential of electrified BRPs (eBRPs), but further optimization by using smaller BRP mesh sizes or optimized electric stimuli is warranted to retain all marketable sole.

Towards a better understanding of the adoption of new fishing technology by Belgian fishers (cont.)

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In Western Europe, fish stocks are under pressure and as a consequence so are their associated fisheries. In addition, fishing, and particularly practices employing towed bottom contact gears, have a major impact on benthic ecosystems (Løkkeborg, 2005). This is the case for the mixed demersal fishery in the North Sea. In the Belgian fleet 77% of the landings is accounted for by beam trawlers (Tessens, 2015).

For these reasons, technical and management measures are being developed in an attempt to lower the impact of fishing. The choice of fishing technique can make a large difference in impact on the ecosystem as well as in efficiency (e.g. fuel consumption). In addition, when considering a particular gear, there exists a broad series of possible measures to improve selectivity and reduce the number of unwanted species and undersized fish. These measures are often developed by the industry or in science-industry partnerships. Measures such as escape panels, lighter netting, replacement of the traditional beam with more hydrodynamic structures (e.g. sumwing), replacement of the trawl heads with rollers (e.g. ecoroll beam) have proven successful in reducing bycatch, fuel consumption or bottom impact (or a combination of these) (Depestele *et al.*, 2007; Polet *et al.*, 2010; Poos *et al.*, 2013).

However, the diffusion of technical innovations in fisheries has been observed to be a slow process. As is the case in the agricultural sector, it can be assumed that the adoption of new technologies rarely happens on its own and adoption decisions are very likely to be influenced by changes in external factors (Wauters *et al.*, 2005; D' Emden *et al.*, 2006). Therefore, the focus of this study is to identify the factors associated with the decision to adopt and invest in new fishing technology. This study is a first attempt to investigate the drivers and attitudes behind the uptake of new fishing technologies by Belgian fishers.

Fifteen Belgian fishers were selected and invited for a semi-structured open interview in the period January-March 2016. Prior to the interviews, we listed a set of possible themes related to fisher attitude and behaviour. Additional themes that come up frequently during the interviews will be recorded, as well as the perceived link between themes and mentioned associations. These will be described and divergent views will be used to challenge generalizations. The results are expected to indicate that besides profitability, a number of other drivers play a role in adoption behaviour and investment decisions (social relationships among fishers, external factors such as subsidies and fuel prices, pressure from the producer organization or policy-makers, etc.). Knowing the factors that hamper or facilitate the adoption of innovative techniques can be important for the implementation of management measures aiming for sustainable fisheries.

VALDUVIS: An innovative approach to assess the sustainability of fishing activities (cont.)

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The Belgian fishing sector is under pressure to demonstrate the sustainability of its fishing methods. First, the beam trawl (which accounts for 80% of the landings) is contested due to its low selectivity and significant disturbance of the seabed. Second, the Belgian retail market has committed to sourcing sustainable seafood. However, converting to sustainable methods is costly and may not be feasible for the majority of fishers who have suffered economic losses in the wake of the 2008 fuel crisis. Instead of a full-scale transition to sustainable fishing, fishers have developed modifications to the beam trawl that reduce environmental impact and save fuel. We propose an indicator-based sustainability assessment tool (VALDUVIS) that recognizes these efforts and offers incentives for fishers to adopt more sustainable fishing practices. In this article, we describe the development of the tool and its potential applications. Integrated Sustainability Assessment (ISA) was used as a framework to develop the tool and to initiate the transition towards sustainability in the Belgian fishery. VALDUVIS offers a promising new method to assess sustainability in fisheries. The approach is innovative in several ways. First, indicator scores are calculated using official data flows (e.g. the electronic logbook), which enhances traceability and provides the possibility of communicating sustainability data soon after landing the fish. Second, indicators are scored on a fine scale (e.g. per fishing trip). Third, stakeholder participation was essential in the development of the tool. This enhanced the support of the wider fishing sector and assured the relevance of the indicators and the users' understanding of the tool. Fourth, the delivered tool is multi-purpose and can be easily adapted to the needs of a range of end-users (fishers, wholesalers, retailers, authorities, researchers, etc.). The VALDUVIS tool offers a cost-effective alternative to known certification schemes that could be applied to any type of fishery. The Belgian fishing sector considers VALDUVIS to be suitable for monitoring the progress towards sustainability as well as for providing incentives for fishers to adopt better practices.

Injury, reflex impairment, and survival of beam trawled flatfish (cont.)

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Under the 'high survival' exemption of the European landing obligation or discard ban, monitoring vitality and survival of European flatfish becomes relevant to a discard-intensive beam trawl fishery. The reflex action mortality predictor (RAMP) method may be useful in this context. It involves scoring for the presence or absence of natural animal reflexes to generate an impairment score which is then correlated with post-release or discard mortality. In our first experiment, we determined suitable candidate reflexes for acclimated, laboratory-held European plaice (Pleuronectes platessa) and common sole (*Solea solea*). In a second experiment, we quantified reflex impairment of commercially trawled-and-handled plaice and sole in response to commercial fishing stressors. In a third experiment, we tested whether a combined reflex impairment and injury (vitality) score of plaice was correlated with delayed post-release mortality to establish RAMP. Five-hundred-fourteen trawled-and-discarded plaice and 176 sole were assessed for experimentally confirmed reflexes such as righting, evasion, stabilize, and tail grab, among others. Of these fish, 316 plaice were monitored for at least 14 days in captivity, alongside 60 control plaice. All control fish survived, together with an average of 50% (±29 SD) plaice after being trawled from conventional, 60-min trawls and sorted onboard a coastal beam trawler. Stressors such as trawl duration, wave height, air and seawater temperature, were not as relevant as a vitality score and total length in predicting post-release survival probability. In the second experiment where survival was not assessed, reflex impairment of plaice became more frequent with prolonged air exposure. For sole, a researcher handling-and-reflex scoring bias rather than a fishing stressor may have confounded results. Scoring a larger number of individuals for injuries and reflexes from a representative selection of trawls and trips may allow for a fleet-scale discard survival estimate to facilitate implementation of the discard ban.

Shrimp pulse trawling (trials)

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ILVO explored discard reduction possibilities with a pulse trawl in shrimp fisheries. A catch comparison was conducted on the commercial vessel "O 82". A pulse trawl was compared simultaneously with a traditional shrimp trawl. Various trips were sampled in March, June, September and December 2016. The shrimp catch was more efficient with the pulse trawl as compared to the traditional shrimp trawl (+15%). Less undersized shrimp were caught with the pulse trawl (-25% per litre commercial shrimp).

Contribution to the DiscardLess project

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Project outline: The Horizon 2020 'DiscardLess' project will provide the knowledge, tools, and methods required for the successful reduction of discards in European fisheries. To achieve this, DiscardLess will work through collaborations between scientists, stakeholders and policy-makers to support and promote practical, achievable, acceptable and cost-effective discards mitigation strategies, and to make the EU landing obligation functional, credible and legitimate.

Related to the contribution of ILVO: Within the project, a catalogue of fact sheets was assembled which provides brief descriptions of many of the catch comparison and selectivity trials that have taken place in the North Atlantic and adjacent seas. This is to highlight the potential gear modifications that can be made and to provide an indication of their likely effect. It is important to bring together this type of information and to disseminate it as broadly as possible. Not only will the preferred selective performance differ at a fishery by fishery level, it may also vary at a vessel by vessel level, as individual fishers may wish to tailor their gears to the specific catch and quota restrictions they may face and/or to optimize their response to the prevailing market forces. Furthermore, the catalogue of factsheets is by no means exhaustive, indeed, it is just a starting point that needs to be added to and built upon. ILVO has added topic sheets on some of the latest adaptations tested to improve selectivity in the beam trawl flatfish fisheries.

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11.3 France

The technological works led in France in 2016 are distributed in 3 main topics:

- Improvement of selectivity/species survival;
- Impact on the seabed and energy savings;
- Alternative fishing gears.

11.3.1 Improvement of selectivity / species survival

"REDRESSE" project : selectivity in the Bay of Biscay

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The objectives of this project are to test strategies and devices allowing to reduce discards of the fishing fleets in the Bay of Biscay. This project concerns the following "*métiers*":

- Bottom trawlers: Nephrops and fish;
- Netters: gillnet and trammelnet;
- Pelagic trawlers: small pelagic fish and tuna;
- Danish seine: whiting and red mullet.

The project leader is the AGLIA (Association du Grand Littoral Atlantique). Other partners are Ifremer, CNPMEM (French National Fishers Committee) and the South-western Waters RAC (Regional Advisory Council). The financial partners are « France Filière Pêche » association and the 4 Regions Councils of the Atlantic façade, Brittany, Pays de la Loire, Poitou-Charentes and Aquitaine.

This 3 years and a half project will end mid-2017.

Several devices were tested both for *Nephrops* and fish métiers.

Nephrops Métier

"Fish devices"

- "scaring" float associated to the "100 mm hake mandatory square mesh panel (SMP)"
- Large 90 mm square mesh panel (SMP) in the "baitings" (in the last tapered section) in addition to the mandatory hake
- 90 mm diamond mesh extension

"*Nephrops* devices"

- 55 mm T90 in codend or extension (without codend)
- 60 mm SMP on the belly of the extension (6 m long)
- New Nephrops hinged grid in polyurethane (6 pieces, 13 mm bars spacing)

"*Nephrops* and fish devices"

- Separator panel (horizontal)
- Reduction of the number of meshes from 100 to 80 at the circumference of the extension.

Fish Métier

"Monkfish/megrim fishery"

- 100 mm T90 (all the extension, not in codend)
- SMP on the bottom of the extension

"Fish/cephalopods devices"

- 70 mm T90 extension
- 80 mm square mesh cylinder (SMC) with or without scaring float
- 100 mm SMC
- 100 mm T90 cylinder
- 120 mm SMP on the top of the extension

The results obtained with all these devices with be summed up in a report edited mid 2017.

"CELSELEC Project" : Improvement of selectivity in the Celtic Sea

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Monkfish Grid

The trials carried out in 2015 with observers on board had shown over time a premature deterioration of the semi-elliptic grid in polyurethane (one piece), with in particular a broken bar.

Thus, Ifremer suggested pursuing the trials with new models of articulated or supple grids. This proposal was validated in Steering committee.

The main objective remains to favor the escapement of the small anglerfish, but also the small dabs and skates. The flexible or articulated design should limit the risks of deterioration of the grids in the trawl and on the drums. Taking into account their advantage to be supple or articulated, the surface of some of these grids was increased with regard to the previous trials, which should also increase their efficiency.

The periods of experiment spread out from 01/07/2016 till 31/12/2016 and fishing zones from Celtic sea (7e,h,j) to Bay of Biscay (8a,d).

3 types of grids were tested:

- semi-elliptic articulated polyurethane grid in 4 pieces, rough dimensions 975 mm x 1140 mm (opening of 50 mm x 110 mm).
- rectangular supple grid in rope strengthened by rubber tubes, rough dimensions(size) 1000 mm x 1105 mm (theoretical openings of 50 mm x 110 mm).
- rectangular supple grid in rope strengthened by rubber tubes, rough dimensions(size) 1045 mm x 1075 mm (theoretical openings of 50 mm x 120 mm).

The best mechanical and quantitative results were obtained with the third type supple grid.

There was a large reduction of benthic fish and flatfish and a large reduction of cephalopod discards. There may also be some commercial losses of sole. The grid does not affect the retention of gadoids, rays and pouts and the catch of anglerfish (by weight) was not affected, however, small individuals (<30 cm) escaped through the grid.

"REJEMCELEC Project": Decreasing discards in the Channel and in the Celtic Sea

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The objectives are identical with those of the CELSELEC and REDRESSE projects but focus on the trawling fishery operating in Channel and target more particularly the following species: whiting, haddock, boarfish, horse mackerel, gurnards,

The leader of the project is the fishers' organization "COBRENORD" (Northern Brittany) in partnership with OPN (Fishers organization of Normandy). Other partners of the project are Ifremer and the equipment manufacturer Naberan. The funding partners are the association « France Filière Pêche » and the Brittany and Normandy Region Councils.

The experiments started in 2016 in the Channel. Preliminary trials were carried out on two types of devices aiming to decrease discards of haddock, whiting, horse mackerel, mackerel and grey gurnard, while keeping as much as possible squids and commercial sizes of gadidea:

- Two large 90 mm square mesh panels in the top of the "baitings" (last tapered section of the trawl, before the extension).
- A large 90 mm square mesh panel in the top of the extension.

The objective of the **large 90 mm square mesh panel (2 pieces) in the top of the "baitings"** is to propose a large surface of square meshes for escapement of Gadidea and other species under commercial size while limiting the losses of squids and commercial whiting, on the basis of the study of their behaviour in the trawlnet.

This device was the object of a preliminary experiment on one boat in Roscoff at the beginning of September, 2016. For technical reasons, the surface is realized in 2 panels.

The 2 panels measure approximately 6.50 m x 3.30 m and 4.20 m x 2.50m.

They allowed a significant escape of mackerels during the preliminary trials. On the other hand, no discards of whiting was observed either in the standard trawl or in the selective trawl and it was not thus possible to quantify the efficiency of the device for the small whiting. Video observations videos of whiting escapees were however realized.

Video footages of very good quality were obtained with and without artificial light at 85m depth.

The **large 90 mm square mesh panel in the top of the extension** aims at limiting the discards of fish while avoiding escapement of targeted sizes of whiting, squids and cuttlefish. Its dimensions are approximately of 4.50 m x 1.15 m and it is set with four sides instead of two in order to improve the vertical opening of extension. Based on video observation, it is assumed that squids usually stay at the middle of the trawl to go straight to the codend. The better vertical opening might decrease the probability for squids to touch the net and to escape.

This device was tested in a preliminary experiment in the Western Channel at the end of October, 2016.

Its setting on the top of a 4 sides extension is to be improved because the opening of the extension was not optimal. The first very preliminary analyses show however an important escapement of whiting up to 40 cm. These trials are going on in 2017 with several modifications on the device.

FUSION – PRONOSTIC project to determine the selective properties of a T90 cylinder

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In the Bay of Biscay, the selective properties of otter trawls have mainly been studied with regard to single species. However, for bottom trawl mixed fisheries targeting fish, it remains challenging to find a selective device capable of limiting catches of small individuals of several species without commercial losses. The present study focuses on an innovative technical solution to reduce catches of undersized individuals in a multispecies bottom-trawl fishery in the Bay of Biscay. We present results for six commercial species obtained using a cylinder composed of 100 mm T90 meshes mounted in the extension piece. This device is efficient at allowing the escape of small Solea solea, Trachurus trachurus and Spondyliosoma cantharus individuals. No commercial losses of Sepia officinalis were recorded. Patterns for Dicentrarchus labrax and Mullus surmuletus require further investigation due to limited fish size ranges in the dataset.

"ENSURE" project : Evaluation of discards survival

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This project was launched in June 2014 and will run until end 2016. It is carried out by Ifremer. The other partners are the " Haute Normandie" Fishers Committee, "Nord Pas de Calais" Fishers Committee and "Pays de la Loire" Fishers Committee. The project is financed by the association France Filière Pêche and by the Fisheries and Aquaculture French Authority.

By 2019, the Common Fisheries Policy will prohibit discarding in all European fisheries of any pelagic, demersal or shellfish species for which removals are managed by TACs and quotas or minimum sizes. However, the regulation allows for exemptions from the prohibition for species for which scientific evidence demonstrates high survival rates associated with discarding. Producing reliable evidence of high survival typically requires long and costly studies involving tagging or captivity. The first part of the project proposes to use the capacity to resist air exposure, a key stressor for discarded animals, as a proxy for survival that can be used to prioritize candidate species for more in-depth discard survival studies. The time required to induce mortality (TM) in air-exposed fish was estimated for ten discarded species under commercial fishing conditions for two artisanal French otter trawlers in the Bay of Biscay and in the English Channel. European sea bass, plaice, sole and skates had extended TM values on average, suggesting that these species are good candidates. The three species observed in both regions (plaice, sole and skates) had larger TM values in the English Channel experiment compared to the Bay of Biscay experiment. Among the four measured external conditions that could influence TM (air temperature, fish length, tow depth and tow duration), the air temperature was the most important and the factor that most distinguished the two experiments.

Among species presenting survival potential, Pleuronectes platessa is one of the most discarded in the coastal otter trawl fishery in the English Channel. The second objective of the study was to provide the most reliable estimate of its survival after release in commercial conditions, and to identify the influencing factors of this survival. A captivity experiment was conducted in January-February in the English fishery to assess the survival of discarded plaice depending on a semi-quantitative index of fish vitality, which has demonstrated to be a good proxy of fish survival in comparable fishing and environmental conditions. This study examined the potential of this index to estimate discard survival in three trials from the English and French fisheries and at three different seasons. The vitality index was then used to analyse the influence of several factors (fishing practices, environmental conditions and fish biological characteristics) on the discard survival.

SURTINE project to assess the survival rate of Nephrops discarded from trawlers in the Bay of Biscay

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In the context of the landing obligation set by the new Common Fisheries Policy (CFP), Norway lobster *Nephrops* norvegicus was identified as a species likely to have high survival rate when discarded in the bottom-trawl fishery of the Bay of Biscay. Previous studies in this area reported a survival rate between 30% and 51%, but the experiment was done on a limited monitoring period and the seasonal variations were not investigated. This study was designed to obtain a reliable value for survival rate after a 14-day monitoring period in onshore tanks allowing to take delayed mortality into account. The study also tested the effect on the survival rate of using a discarding chute system, a sorting device that was made mandatory on the 1st of January 2017 for *Nephrops* trawlers in the Bay of Biscay. This device, which allows fishers to discard undersized *Nephrops* back to the sea while sorting, led to an increased average survival rate (51.2%) compared with the standard sorting practice (36.9%). The impact of biological, environmental and fishing operation related variables on survival from the first day of captivity to the end of the monitoring period was examined using a generalized linear model. The results of this GLM indicate that injuries, season and duration of the air exposure, significantly influence the survival.

11.3.2 Impact on the seabed and energy savings

TETRIS project Evaluation of trawling impact on benthic communities

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Trawling activities are considered as one of the main source of disturbance for the seabed worldwide. The Grande Vasière, is one of the major French trawl fishing ground. In this project, we aimed to disentangle the dominance of environmental variation and trawling intensity to explain the distribution of diversity patterns over 152 sampling sites. Using a non-extractive method, a towed underwater video device, we identified 39 taxa to the finest taxonomical level possible, which were clustered according to their vulnerability to trawling disturbance, based on functional traits. Using generalized linear models, we investigated whether the abundance distribution of each vulnerability group was sensitive to trawling intensity and habitat characteristics. Our analyses revealed a spatial structure of community with a structuring effect of depth and substratum. The distributions of the more vulnerable groups were negative functions of trawling intensity while only the distribution of the less vulnerable group was independent from trawling intensity. We advocate that such trait-based vulnerability assessment of communities might be more relevant than the traditional taxonomic approach to identify and integrate the most vulnerable areas to fishing activities in seascape or conservation planning.

11.3.3 Alternative fishing gears

"Large fish pots" experiments

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This project is funded by the Fisheries and Aquaculture French Authority, in a general program aiming to improve selectivity.

2 new types of fish pots of large dimensions were built, one on a model of fish pot tested in Norway in the vicinity of salmon cages, the other one on a collapsible con-

cept developed by Ifremer. In both cases, the idea is to test the potential of capture of fish pots of large dimensions, on species other than conger, pout or cod, for example sea bass, sea bream or pollack.

The experiments were carried out on 3 sites: in Brest harbour (Logonna Daoulas), in the entrance of the Gulf of Morbihan (Locmariaquer) and in the Bay of Quiberon.

The trials were conducted in areas known for a great abundance of targeted fish at the periods of the test (August/September). But this abundance of fish (sea breams, sea bass, etc., according to places) is bound to the abundance of food (mussels, oysters, spat of oysters) on the chosen zones. We can wonder if bait put in the fish pots, such as mussels crushed or not, oysters or fish (anchovy) can still be attractive if the species of fish targeted can find very good food in abundance outside the fish pots. Besides, it would seem that "the shelter effect" expected by covering the top of certain fish pots with very small plastic meshing, so as to darken the inside, is not at all obvious.

It is the case in particular for gilthead sea breams, filmed in number in front (1 or 2 meters) of fish pots at Locmariaquer, but none of them penetrates into the pots of various types.

The only significant catch was the one of triggerfish and black sea breams on the site of Logonna-Daoulas by rising tide coefficient from 64 to 93, in the middle of August 2016, with 48 hours immersion. It is the first significant catch of species other than conger or pout (or toothfish in the Southern fisheries) that we realized during the trials of fish pots carried out for several years by Ifremer.

Besides, it seems necessary to avoid too long durations of immersion which increase the risk of exit of the possibly captured individuals. A duration of 24 hours seems ideal, at the most 48 hours. Triggerfish of very big size, observed from the surface after 24 hours, indeed escape from one of the large fish pot (Norwegian type non-dismountable), before hauling at 48 hours. A logistic of hauling every 24 hours is necessary.

Two strategies could be applied for new experiments:

- Zones with presence of important concentrations of targeted fish attracted by the available food in quantity, but to which we propose another type of bait very attractive for them (example: gilthead sea breams or sea bass attracted by mussels or oysters farming zones, but to which we propose cuttlefish bait for example).
- Zones with presence of targeted fish but without important concentrations attracted by the food in quantity; the bait could be crushed oysters or mussels in that case.

"PASAMER" project, experimental longline for black scaboard and hake fishing

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"Pasamer" was a national co-funded project involving Scapêche fishing company (2014–2016). It aimed at settling profitable longline fishing for a 33 m trawler converted to longliner to reduce by catch, fuel consumption and physical impacts on the seabed. A first period was dedicated to the training of the crew who was new to this métier. This period was based on the use of benthic automatic longlines with 9mm main line. The fishing company objective is also to target hake and black scaboard in deep waters. Thus off-bottom longlines have been designed, using a simulation tool developed for this project. A sea trial was undertaken by the end of 2015. Measurements using depth sensors were achieved on off-bottom and benthic longlines in order to validate simulation results. Sinking velocity, which is important for the bait efficiency, and longline shapes were found in good accordance with the model prediction. We noticed a strong effect of undercurrents on the line behavior, and unfortunately low catch of pelagic fish, presumably due to the choice of working areas. Fishing trials in commercial condition where undertaken during one year. These trials show that this technic is not efficient to fish the target species, or more precisely, catches are not sufficient compared to the exploitation costs of the longliner with its 13 crew members. However, we think this technic could be interesting for smaller vessels targeting high valued species like Sparidae (sea bream) and gadoids.

11.4 Germany

11.4.1 Institute: Thünen-Insitute for Baltic Sea fisheries (TI-OF), Rostock

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Investigating codend size selection in the Celtic Sea trawl fishery targeting megrim, monkfish and make.

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The Bycatch rates in some bottom-trawl mixed fisheries in western European waters remain on inadmissible high levels. This is the case of the Spanish fishery targeting Megrim, Monkfish and Hake in the Celtic Sea (Grand Sole Bank). A collaborative project between Cooperativa de Armadores de Vigo (ARVI-Spain), Instituto Espanol de Oceanografía (IEO-Spain) and Thünen Institute, started in 2016 with the main aim of investigating ways of improving codend selectivity in the fishery, as a first step to address the bycatch problem. The project involves testing a number of codends varying in mesh size, mesh configuration and number of meshes in circumference, using the 64,50 m, 2900 kW German vessel Walter Herwig III. The Experimental and commercial codends, cover codends and the commercial trawl to be used was delivered by ARVI and mounted in the German vessel in February 2016. A sort research cruise was conducted subsequently between 03.03. and 14.03.2016 in the Irish fishing grounds. The interim goals of the cruise were i) to adapt the Spanish trawl to the research vessel, ii) to conduct the first experimental hauls with cover codend, and iii) to collect lab fall through data using a grid of different mesh sizes and mesh opening angles. The trawl was successfully rigged and the first hauls were conducted in the targeted fishery. No experimental size selection data were collected due to technical problems with the cover codends, and the hard weather conditions during the fishing days available. Experimental fishing to be resumed in June 2017 (06.06–04.07.2017).

HESPAN and SepNep. Investigations on bycatch reduction in the North sea *Nephrops* fisheries (Cruise SO725 with FRV "Solea"; 09/2016).

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How to supplement the codend selectivity in *Nephrops* trawls to reduce the bycatch of fish species has been a main topic of research during decades, resulting in different technical solutions, some already implemented commercially. Although the great efforts invested on the development of these devices, it has been demonstrated that none of them are effective enough to drastically reduce bycatch. Under the Landing Obligation (LO) adopted by the European Common Fisheries Policy (CFP) reform (EU1380/2013), further efforts are required to achieve more efficient solutions.

HESPAN is the alternative solution proposed by the Thünen Institute, developed and tested for first time in Skagerrak sea in September 2015. The concept is based on mounting a sieve panel to split *Nephrops* and fish into separated codends (Figure 11.4.1). An efficient separation would allow using codends with adapted selectivity for each of the catch fractions, considering the market preferences and the quotas restrictions imposed by the EU LO. HESPAN was presented for first time to the fishing technology community in the ICES-FAO WGFTFB (Mérida-México, 24–29 April). During the Working Group, colleagues from Wageningen Marine Research Institute (Netherlands) shared information about SepNep, a selection device similar to HESPAN, designed and tested in commercial conditions by the Dutch Fisher and netmaker Kees van Eekelen.

The conceptual analogies of HESPAN and SepNep, and the need of understanding and optimizing both 2015 designs, were strong arguments to work together for further developing and testing both gears in the same experimental and fishing conditions. A joint research cruise to be conducted in the North Sea was planned for this purpose, becoming a good opportunity to exchange experiences between the researchers and fisher involved, and to enhance the collaboration framework.

The joint research cruise SO725 was conducted in September 2016 in Dutch and German *Nephrops* fishing grounds, using the German RV/Solea. Two new HESPAN designs were tested during the cruise, being shorter, more handling and resistant than the 2015 versions. On the other hand, SepNep gear was updated by incorporating an innovative grid in the lower compartment to select *Nephrops* by size (Figure 11.4.2).

The results demonstrated both concepts to be efficient at separating *Nephrops* from fish species. The percentage of sized *Nephrops* sieved into the lower codends varied between 75% and 90%. The best SepNep design showed slightly better sieving efficiency than the best HESPAN, at expenses of allowing more fish entering in the lower compartment. On the other hand, the innovative grid mounted in the lower compartment of the SepNep delivered a sharp size selection on *Nephrops*, that make it a promising alternative to improve the poor species size selection delivered by the standard codends.

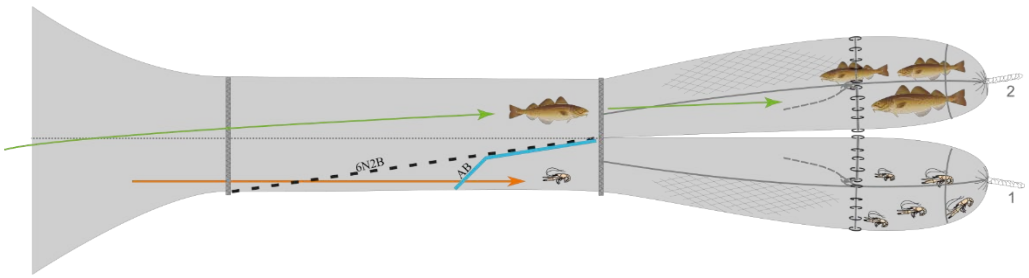

Figure 11.4.1. Side view of the experimental gear mounting the 2015 HESPAN general design, represented by the black dotted oblique line, and the 2016 design (blue line).

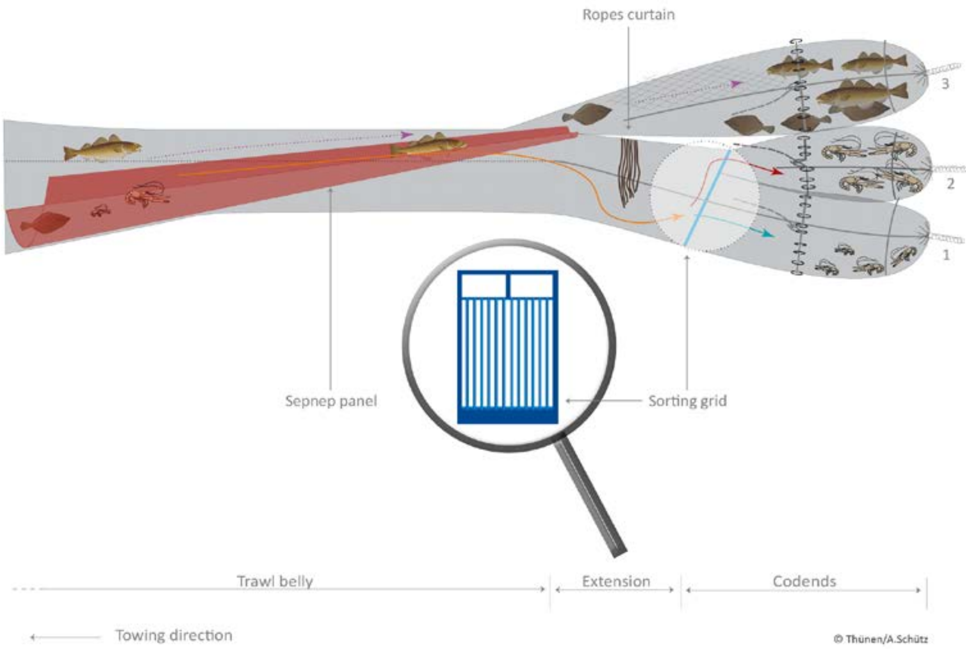

Figure 11.4.2. Side view of SepNep gear illustrating the expected functioning of the SepNep sievenet (red) and the Nephrops grid (blue). Codend numbering (1=lower codend, 2=mid codend and 3=upper codend).

What is successful in avoiding flatfish bycatch, can it be successful in avoiding cod bycatch? From the FLEX to the iFLEX and a new application for SORTEX 1. (Cruise SO727 with FRV "Solea"; 10-11/2016 and Cruise CLU308 with FRV "Clupea"; 12/2016)

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For 2017, the catch quota for the western Baltic cod stock was reduced by 56% and the quota for the eastern Baltic cod stock by 25%. Furthermore, with the implementation of the landing obligation for TAC-species, fish shall not be discarded at sea. The combination of low TAC for cod and landing obligation results in a theoretical problem: flatfish fishery has to stop when the cod quota is exhausted, in case it is not possible to avoid the catch of cod. Therefore, solutions must be developed to be able to fish on the existing flatfish stock without significant cod bycatch.

In this reporting period, three trawl extension devices were tested with which cod and flatfish can be separated from each other. Two of these studied species selection devices, a) the rectangle-frame "FLEX" and "SORTEX 1", have already been developed and tested for the reduction of flatfish in the fishery targeting cod.

With the rectangular frame FLEX (see national report and presentation on WGFTFB 2016) the flatfish catch was reduced by 90%, without losses in the cod catch. Now, to avoid cod bycatches in a flat fish directed fisheries, a codend was installed on the exit opening originally intended for flatfish, but the extension usually equipped with a codend was left open. The principle was called iFLEX (inverted FLEX). This selection device reduced the number of cod by 63% (catch weight by 65%). The losses in flat fish catches in numbers are 5% for flounder and 20% for plaice, these losses in weight are 3% for flounder and 18% for plaice.

SORTEX 1 is a netting- steelframe device to split flatfish and roundfish in demersal trawl catches (see national report WGFTFB 2016). This principle consists of a net panel made of large meshes in T90 orientation, which is mounted obliquely in the extension of the trawl. The oblique separator panel split the aft of the trawl in two longitudinal spaces - lower and upper-, ending in two separated codends (upper and bottom codend). The forward edge of the oblique panel is mounted to a rigid square frame with 20 cm height, leaving a free passage for flatfish to the lower codend. Roundfish species should be driven by the bottom–up inclination of the panel towards the upper codend, while flatfish might enter in the lower codend by i) passing through the rigid frame surface, or ii) passing through the T90 meshes of the oblique panel towards the lower codend. In this report period the SORTEX 1 was tested with the shortest and simplest separator panel to verify how much cod can be separated from flatfish. However, 73% of the total caught cod were found in the upper codend and only 6% of the total flounders and plaice caught in the upper codend of the sorting device.

Both FLEX and SORTEX 1 contain a rigid 92 x 25 cm stainless steel frame. In contrast to the principle of the FLEX, SORTEX 1 is additionally equipped with a sorting and guiding net panel in the lower half of the trawl extension. Both extensions are deviating from the usual two selvedge and two net panel trawlnets and two selvedge codends in the selection area, they consisted there of four net panels with four selvedges. The SORTEX 2 extension does not contain any rigid elements and is intended to be installed on the trawlnet like a conventional two-panel extension. The shape should be ensured solely by hydrodynamic forces, buoyancy and weighting forces and a special cutting plan of the lower panel. On the cruise SOLEA 727, SORTEX 1 and SORTEX 2 were tested side-by-side on the double belly trawl (DBT) at the same time. Under the experimental conditions of these trials, SORTEX 2 contained 67% of the cod, 6% of the flounders and 11% of the plaice in the upper codend of the device.

STELLA, Development of alternative management approaches and fishing techniques to minimize conflicts between conservation objectives and gillnet fisheries

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Fishing with gillnets is one of the most common fishing methods worldwide. Along the German Baltic Sea coastline, local gillnet fisheries provide a source of income for a number of families, form a part of the cultural heritage and play a major role in the touristic attraction of the coastal region. Fishing takes place within and outside the special protected areas, which make up around 44% of the German EEZ in the Baltic Sea. Large flocks of migratory birds pass through every season and rest within these areas. Furthermore, there is a small population of harbour porpoise in the Western Baltic. While gillnet fishing is a highly size selective fishing method, unwanted bycatch includes higher trophic species like harbour porpoises and seabirds. Data on the extent of the problem is rare, since gillnet fishing is usually carried out on small vessels (often less than 12 m in length) and fishers are often only obligated to deliver a monthly catch report on these vessels without any indication of bycatches.

Previous mitigation attempts to tackle this issue include spatial and temporal exclusion of fisheries, raising the acoustic reflectivity and optical visibility of gillnets to alert porpoises and deter birds, as well as using alternative fishing gear such as longlines or traps. These attempts have been relatively uncoordinated and usually only included one aspect or method to approach the issue. In STELLA (11/2016-2019) we combine a total of four working packages to tackle the bycatch problem from all angles and find a solution that is effective, sustainable and will find acceptance among fishers. The project comprises the following: 1) estimating fishing effort of the local gillnet fisheries and identifying behavior patterns of different fisher groups. 2) development of gillnet modifications to minimize bycatch of marine mammals and seabirds 3) development of alternative fishing gears 4) analyse motives of fishers and identify incentives that may lead to enhanced acceptance of mitigation methods.

The beach-seine fishery in Miankaleh Peninsula

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Miankaleh peninsula is a 48 km long peninsula in the north of Iran, located in the extreme southeastern part of the Caspian Sea. The peninsula hosts a number of fishers' communities, inhabiting the narrow peninsula during six months per year to conduct a seasonal beach-seine fishery. Normally, each community conduct one haul per day, therefore, an extensive marine area is swept daily during the season, endangering the fish populations and the ecological balance of the natural enclave. A project led by Saied Gorgin from the University of Gorgan aims to investigate the fishing technology, fishing efficiency and the selectivity of the fishery. Members of the Thünen Institute visited Gorgan University in March 2017 to share expertise and develop an appropriate experimental plan adapted for the special characteristics of the targeted fishery. The visit included a workshop in Gorgan University, and two-days fieldwork in Miankaleh peninsula. The objectives of the project and the experimental design to be implemented were sharpened based on the shared information and the field observations.

Optimizing pulse characteristics for brown shrimp pulsetrawl fishery

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The brown shrimp fishery is a small and regional coastal fishery. Nevertheless, it is the most important German fishery - based on the economic revenues.

The standard gears in this NorthSea-shrimp fishery are beam trawls with a Bobbin-Groundrope. A standard beam trawl (8 m width) has around 36 bobbins. These bobbins have two duties: a) the bobbins guide the net over the bottom and b) they startle shrimp to jump off the bottom.

Unfortunately, the bobbins also stimulate other bottom living species, such as flatfish spe-cies. Usually, those unwanted animals are caught and discarded - a point of criticism. An-other critical point is the bottom contact of the bobbins, which potentially harm the seabed and requires additional energy.

To omit the bobbins (or at least to reduce their number), other ways to stimulate the shrimp have to be found - ideally only the shrimp. One option is the usage of electrical fields. Nevertheless, the general acceptance of this system is quite poor, although no negative short and long-term effects on species are known so far. In order to increase this acceptance, a joint study (ILVO Belgium, Thünen-Institute of Baltic Sea Fisheries Germany, Ifremer Lorient France) was conduct to explore possibilities to reduce the potential interferences with the environment further by optimizing the electric pulse parameters. The brown shrimps' reaction on electric pulses was investigated during a laboratory experiment, conducted at ILVO in Oostende, Belgium. The various focal parameters, in a series of 60 experiments were:

- the number of pulses: 1 to 7
- pulse duration: 0.1 ms, 0.3 ms, and 0.5 ms
- electrode shape: plate and wire
- water temperature: 8 and 16°C

The reaction of the test animals was documented with a high-speed camera with 200 fps. For the data acquisition a tracking software (contact Julien.Simon@ifremer.fr) was used which was able to track the escape path for each shrimp in the high-speed video taken by the camera. The outcome of this tracking software was a video with the escape path line for every shrimp, including X/Y coordinates per frame. Based on these data the following aspects were investigated:

- the startling threshold and the reached heights;
- lead time for pulsing in front of the net;
- natural tail flip frequency.

Reviewing the results, it became obvious that the pulse duration can be reduced from commonly used 0.5 ms to 0.3 ms. In conditions, where an activation effect for buried shrimps is of less importance and/or in warmer water temperatures, even 0.1 ms is sufficient. Relating to the question of the optimal number of pulses, it could be shown, that more than six pulses did not improve the results. A pulse rate of five pulses with a lead time of 1000 ms should be sufficient. As could be expected from the fishing results during warmer and colder seasons, lower water temperatures lead to lower heights of shrimp in response to the pulses and in consequence to lower catch rates. The optimal choice of pulse parameters offers a great potential for improving the pulse trawl system – as show in this study. In addition, the variation of the electrical potential (voltage per meter) between the electrodes which was not in the focus of this study, could help to separate smaller from bigger, market sized shrimps already in front of the net. Covariables like water temperature or visibility are also likely to be significant. This implies that it might be necessary to design flexible systems, which can be easily adapted to actual water conditions in order to always get the minimal environmental impact for optimal catch rates and gradually decrease bycatch rates.

11.5 Spain

11.5.1 AZTI-Tecnalia – Fishing Technology Area

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The projects described below have been developed by AZTI-Tecnalia during last years, some of them have been finished and the other are ongoing projects. The projects have been developed in the new scenario of the European Fisheries Policy specially in the areas affected by the landing obligation.

Fish survival from slipping in purse-seine fisheries: the case study of European southern waters

Slipping (releasing fish before the net is fully hauled onboard if the catch is unwanted by the skipper) has been prohibited by the European fisheries regulation (Regulation EU No 227/2013) for herring (*Clupea harengus*), mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). In the new regulatory framework (Regulation EU No 1380/2013; Article 15), an exemption to the landing obligation can be provided for species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem.

This study presents the results of experimental tests on survivability of several species subject to slipping in southern European purse-seine fisheries, i.e. mackerel, horse mackerel, anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), and chub mackerel (*Scomber japonicus*). Tests were carried out on board a commercial fishing vessel, which is representative of the purse-seine fleet of European southern waters; and they were conducted during real commercial fishing activity. High survival rates were found in the tests, particularly for crowding times of less than 10 minutes. This also suggests that the approach followed to simulate slipping, i.e. using fish tanks filled up with seawater on board to keep the catch in captivity, is suitable for discard survival studies as an alternative to other methods. This project finalized in 2015 but in 2016 a new project with similar objectives started, this ongoing project is expected to finish in 2018.

DESMAN (Discards Handling)

The new European regulations related to the landing obligation for all species with TAC have been applied in certain fisheries in 2015. The new scenario may involve a radical change in the fishing operational processes and handling onboard the fishing vessels.

Focusing on the handling of unwanted catch, it will mean a substantial increase in fish to be separate, classify, conserve, store, transport onboard and land, especially in some fishing methods such as trawling, where the discard levels still quite high.

This is an ongoing project that aims to: i) quantify the volume of the different unwanted species that could be associated to the fishing operations in the Basque fishing fleet, taking into account different fishing methods (inshore, offshore and artisanal fishing fleets).ii) Assess the added effort and operational possibilities for different fishing boats to address the increased workload by handling due to the landing obligation. iii) Study the existing technical possibilities and new work processes to solve the problem of extra fish to be handled. iv) Evaluate the potential increase in risks and their implications on the job security of the crews that will manipulate extra fish linked to compliance with the landing obligation. In spite this project finalized in 2015 a new edition of this project with similar objectives is ongoing during 2017.

Discard survival estimation and improvement in small pelagic purse-seine fisheries

The overall aim of this study was to analyse the survival of discarded species in the purse-seine fleet of the Basque Country in order to provide arguments to discuss technically and scientifically exemption of the landing obligation.

This is an ongoing project where we are trying to: i) Get discard survival rates according to the operational fleet. ii) Study the performance of the machinery or equipment on board that affect survival. iii) Identify and analyse the factors that determine the survival of discards. iv) Development of a good practices manual on catch handling to optimize the survival of discards.

The reasons for the discard in this fishery are the exhaustion of the quota and the absence of commercial value for some species. The main target species of the fishery are anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). These very same species can be discarded in relation with the discard reason mentioned above. The first part of this project finished in 2015 with promising preliminary results and currently we are working on this topic until early 2018.

Selectivity improvement in the trawl fishery targeting hake (*Merluccius merluccius*) in the Bay of Biscay ICES 8abd

The new regulation in relation with discards in the EU waters, named as Landing Obligation or Discard ban, has been implemented to the trawl fishery targeting hake in 2016. According to this regulation all the hake must be landed and registered against quota. The undersized hake must be landed separately from commercial catch and the use of these undersized catches shall be restricted to purposes other than direct human consumption. This is an important drawback for the fishery because it involves that a part of the quota cannot be achieved a return into.

In this context, this project started with the aim of improve selectivity for hake reducing the catch of the juveniles. Two selectivity cruises were carried out on board of pairtrawlers during 2015 and another four cruises during 2016. During some of these cruises hake behavior has been assessed with underwater video and different configurations of a Square Mesh Panel have been tested. In 2017 it is expected to start with selectivity improvement experiments at sea on board of "Baka" bottom trawlers. This project started in 2015 and it is expected to follow working on it until 2018.

Application of FISHSELECT in the Bay of Biscay

FISHSELECT is a method for predicting size selectivity of fishing gears. This method provides guidelines and predictions of selectivity that reduce the amount of trials necessary to develop a suitable gear design for a given fishery, which reduces considerably the economic cost of the selectivity experiments. FISHSELECT is based on morphological measurements of the fish (Cross section contours), fall-through experiment (testing the pass of the fish through different meh sizes and mesh configurations), computer simulations of the fall-through experiments and prediction of selective properties.

The methodology has been applied for some species in the Bay of Biscay. The species selected for this experiment have been Hake (*Merluccius merluccius*) which is an important target species in trawl fishery, Horse mackerel (*Trachurus trachurus*) and Blue whiting (*Micromesistius poutassou*) being both species frequently discarded in trawl fisheries in the area.

The aim of this study has been to identify the more suitable mesh that allows the trawl fleet operating in the Bay of Biscay to fulfill the regulations requirement without being negatively affected by them. This project will be finished in 2017.

Energy performance of fishing vessels and potential savings

Commercial fishing is heavily fuel dependent. The increase in the fuel price, together with the stock decline, occupational risks of fishing, the possibilities of finding a different future for new generations, are some of the reasons that have made fishing arrive at its 'survival limits', in many parts of Europe.

This contribution aims at providing shipowners and researcher with the experience of undertaking energy audits, to reduce the fuel bill of fishing vessels. In order to do so, 3 fishing vessels were assessed comprehensively, for 2010e2012, to determine their energy consumption flow. The results indicate that energy consumption depends upon: (a) the structure and size of the vessel; (b) the engine conditions and use patterns; (c) the fishing gears used; (d) the fishing and trip patterns; (e) the distance to the fishing ground; (f) target species and their migration routes; and (g) the traditions onboard. Likewise, no generalization can be made regarding the way energy is consumed by onboard equipment/machinery when different fishing gears are compared. Energy audits will need to be site-specific and to include sufficient data to obtain representative results; these are likely to be more than in land-based industries, due to the peculiarities of this sector.

On the other hand, this field has a huge potential to improve and still some ongoing projects at AZTI's energy efficiency pilot plant, related to: i) Development of a test bench for the recovery of residual heat from marine diesel engines for energy generation. ii) Tests, under controlled conditions, with fuel consumption and exhaust gases emissions reduction systems on specific test benches.

11.6 United States of America

11.6.1 Massachusetts Division of Marine Fisheries - Conservation Engineering Program

Michael Pol (Report compiler),(mike.pol@state.ma.us), David Chosid

ScanPot: Development of sidescan sonar methodology to survey derelict lobster pots in sandy and rocky habitats in Massachusetts

We measured the efficiency of sidescan sonar to find derelict "ghost" lobster (*Homarus americanus)* pots in March-April 2016 in Buzzards Bay. An area with diverse bottom types was surveyed, and then seeded with a randomized number of pots on 6 different days. An operator naïve to the number set then identified possible pots based on sonar signature in the field and in the laboratory. Detection rates (number of pots found with sonar/number of pots set) were found to be low in simple and complex habitats. Sonar imagery was inconsistent on multiple passes and was often inadequate to reliably differentiate pots from other structures. Future work using sidescan sonar to detect pots requires careful consideration of its efficacy.

ExpandedWhiting: Revision of Existing Whiting Special Access Areas

Special access areas face obsolescence due to temporal and spatial changes in distributions and abundances of fish populations. A two-week experimental fishery in July 2016 collected catch and bycatch data from commercial vessels using the mandatory raised footrope trawl to investigate possible alteration of timing of whiting (*Merluccius bilinearis*) small mesh (64–76 mm) areas, in response to fishers's requests. Preliminary data indicated excessive bycatch of juvenile haddock (*Melanogrammus aeglefinus*); no trends in depth, time of day, or week of haddock catches were observed. Consequently, bycatch mitigation seems unlikely, although the stock of haddock in this area is healthy, potentially allowing for expansion of the timing of the fishery. Another year of data collection will be conducted.

TickleDredge: Bycatch Reduction of the Sea Scallop Fishery

In collaboration with Provincetown Center for Coastal Studies (O. Nichols), we are testing a simple modification to the New Bedford-style scallop (*Plactopecten magellanicus*) dredge to reduce flatfish bycatch by suspending drop chains from the bail. The intent is to physically contact flatfish and skates that are on the bottom, causing them to swim away from the approaching cutting bar and preventing capture in the dredge. A finalized design was developed in March 2017 using video; it maximizes coverage of the dredge path and practicality of attachment. Paired trials are currently underway.

ULOT: The development of an ultra-low-opening groundfish trawl

(Mike Pol; Steve Eayrs – GMRI; Pingguo He – SMAST; Chris Glass – UNH; Jon Knight – Superior Trawl; Jim Ford – F/V Lisa Ann III; Tom Testaverde – F/V Midnight Sun; Dan Murphy – F/V Danny Boy; Carl Bouchard – retired fisher)

In this highly collaborative effort, we have designed an ultra-low opening groundfish trawl (ULOT) to land flatfish and avoid cod, in response to the collapse of the Gulf of Maine stock of Atlantic cod (*Gadus morhua*). Cod quota is so low that it restrains ('chokes') the ability of fishers to land abundant species. We designed the ULOT with a vertical opening of less than 1 m, a reduction of at least 50% compared to contemporary trawl designs for flatfish, and with a headrope 10% longer than the footrope. Several alternative designs were considered by project partners before one was selected for numerical modelling and physical modelling. Post-finalization, 31 valid haul pairs were completed in the Gulf of Maine in May/June 2016 comparing the ULOT with a similar control net. Catch rates of Atlantic cod were significantly reduced using the ULOT, by an average of 42.6 kg h^{-1} or 45.2%; catch rates of five other important species (American plaice *Hippoglossoides platessoides*, yellowtail *flounder Limanda ferruginea*, witch flounder (grey sole) *Glyptocephalus cynoglossus*, American lobster *Homarus americanus*, and unclassified skates, Rajidae) were not found to be different, except for catches of small American plaice (<30 cm); these catch rates were reduced by 27.9%. The ULOT may be considered as a potential option, along with the recent results from topless trawl testing, for fishers to avoid cod with little harm and to access flatfish quotas, and provides further evidence of cod rising while under pursuit by a trawlnet.

Complementary testing of off-bottom trawls to target Georges Bank haddock

In collaboration with Steve Eayrs and with input from Pingguo He, we are initiating a project to equip two groundfish vessels with two different designs of pelagic nets and appropriate doors to fish for haddock and other "groundfish" species (such as Acadian redfish *Sebastes fasciatus*) on Georges Bank; both stocks are currently underutilized. These nets are expected to have low bycatch of weaker stocks, including Atlantic cod and yellowtail flounder. Testing is planned for June-August 2017.

A Modified Sort-X Grid to Reduce the Catch of Juvenile Haddock and Cod in the Georges Bank Haddock Fishery

In partnership with Pingguo He, a project to design and test a "dual-grid" system for eliminating small haddock from a trawlnet before they reach the codend, as a means of protecting small haddock. See more below.

11.6.2 NOAA Fisheries, Northeast Fisheries Science Center (NEFSC), Conservation Engineering Group, Woods Hole, Massachusetts

Henry Milliken (henry.milliken@noaa.gov), Eric Matzen (eric.matzen@noaa.gov)

Cable Sorting Grid – Turtle reduction in the summer flounder fishery

The NEFSC with assistance from the SEFSC performed a comparative test of a cable grid to exclude sea turtles. Previous studies comparing catch rates of Turtle Excluder Device (TED)-equipped trawls and standard flatfish trawls found an average of 25-30% loss in targeted summer flounder (*Paralichthys dentatus*) catch in the TED equipped trawl. As such, additional bycatch reduction devices (e.g. topless trawls, cable grids) are being investigated. In 2016 the NESC was funded to run a comparative study of that catch comparison of a NETIII (a type of cable grid)-equipped trawl to that of a standard flatfish trawl in the summer flounder trawl fishery. The study documented operational issues and compared the catch data aboard two commercial fishing vessels. Aboard the F/V Darana R, significant reductions (29–45%) in summer flounder catch were observed during leg 1 and 2 of the project. Aboard the F/V Jersey Cape, a modified configuration was used and no significant reduction in summer flounder catch was observed. In total, four configurations were tested throughout the study in an attempt to improve target catch efficiency.

From an operational and safety standpoint, the NETIII system was a substantial improvement from previous research using rigid grid TEDs. Because this study proved to be a proof of concept for this gear, with its many modifications, the NEFSC, with assistance from the SEFSC, is planning further research in 2017 on the NETIII system so that it may be used as an alternative to traditional fixed grid TEDs.

Low Profile Gillnet - Turtle reduction in the monkfish gillnet fishery

The NEFSC is investigating the ability of a large (30.5 cm) mesh low profile gillnet to reduce sea turtle bycatch. We are comparing two different tie-down configurations: standard (12 meshes with 1.2 m tie-downs) and low profile (eight meshes with 0.6 m tie-downs) using the same experimental protocol. Previously this configuration proved successful at reducing the bycatch of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) with little effect on the targeted catch of monkfish (*Lophius americanus*) and winter skate (*Leucoraja ocellata*). Sixty paired sets are planned in waters off Cape Hatteras, NC, an area chosen because of the high densities of sea turtles in the winter. This work is expected to be completed in April of 2017.

11.6.3 University of Massachusetts Dartmouth, School for Marine Science and Technology (SMAST) - Department of Fisheries Oceanography, New Bedford, MA

Fish Behavior and Conservation Engineering

Pingguo He (phe@umassd.edu)

Reducing yellowtail and windowpane flounder bycatch: application of a modified European grid system in the Georges Bank haddock fishery.

The fishing industry's full utilization and the maximal benefit of the healthy haddock fishery on Georges Bank (US) rely on the protection of other "choke" species. Recent regulatory restrictions on the Northeast groundfish fishery made it impossible to fully utilize allocations of the robust haddock stock, resulting in 50 to 100 million dollars in foregone revenue. Yellowtail flounder (*Limanda ferruginea*) and windowpane flounder (*Scophthalmus aquosus*) are two of the most severe "choke" species on Georges Bank that impact the successful harvesting of haddock. Reducing these species is thus critical for the fishery that has been plagued by overfishing and stock depletion. The goal of the proposed project is to adapt the successful German flatfish-excluding grid system to the Georges Bank haddock fishery to reduce the catch of yellowtail and windowpane flounder while retaining the catch of legal size haddock. The grid system, constructed of horizontal rigid steel bars, exploits morphological differences and swimming behavior between flatfish and roundfish. Sea trials were completed in spring 2016. Grid spacing of 40 mm and 70 mm were tested. Initial trials indicated that the 40-mm spacing grid was too small for fish to escape. Therefore, the effort was concentrated on the 70-mm grid. Preliminary results indicate that the grid reduced total flounder catch (mainly winter flounder) by 51.3% when using the grid, while there were no differences in the catch of Atlantic cod. Haddock was reduced by almost 40% by weight, but the reduction was mainly for small fish.

A modified Sort-X grid to reduce the catch of juvenile haddock and cod in the Georges Bank haddock fishery.

This new project was in collaboration with Massachusetts Division of Marine Fisheries to test a modified Sort-X grid to reduce undersized haddock to help the long-term sustainability of the haddock fishery. Recent research trips revealed that a large portion of haddock brought to the deck of the vessel was below the minimum landing size when the 165 mm legal size codend was used. Many fish escaped while the codend was on the surface due to slacks and swells. These surface escapees are likely to suffer greater mortality than those escaped while the net is still on the seabed. The reduction in juvenile haddock will also reduce wastes of resource, and unaccounted fishing mortality, leading to healthier stocks and robust fisheries resources. Two sets of Sort-X grid system have been fabricated with 40 and 55 mm spacing. Sea trials will start in spring of 2017.

The Fish Behavior and Conservation Engineering Group is also a partner in the following projects: (1) Migratory delay, predation, and passage success of anadromous river herring and diamondback terrapins in coastal rivers and estuaries of the Cape Cod National Seashore, with US Geological Service. This project uses SoundMetrics' Adaptive Resolution Imaging Soanr (ARIS, a successor of DIDSON) examining movement and behavior of river herring (genus *Alosa*) in Cape Cod National Seashore (Wellfleet, MA) as they migrate upstream through a tidegate structure near the river mouth. (2) The development of an ultra-low-opening groundfish trawl. This project intends to develop an innovative low headline trawl targeting flounders while reducing the catch of Atlantic cod. See ULOT description in Massachusetts Division of Marine Fisheries section by Mike Pol. (3) Complementary testing of off-bottom trawls to target Georges Bank haddock. This project intends to test an off-bottom trawl for traditional groundfish, especially haddock. See description in Massachusetts Division of Marine Fisheries section by Mike Pol.

11.6.4 Gulf of Maine Research Institute (GMRI), Portland, Maine

Steve Eayrs (steve@gmri.org)

Commercial fishing vessel electronic trip reporting pilot study

(Steve Eayrs, Adam Baukus, Aaron Whitman - GMRI)

The goal of this project is to facilitate the use of electronic logbook software by New England groundfish fishers and their transmission of electronic vessel trip reports (eVTRs). The scope of work includes i) working with software providers, sector managers, and the National Marine Fisheries Service to identify and overcome challenges and limitations to effective electronic transmission of VTR data, and ii) facilitating the use of electronic logbook software by New England groundfish fishers. We have now equipped 48 ground fishing vessels (up from 41 last year) with the new eVTR software, although only 21 are currently reporting electronically on a regular basis. From these vessels more than 1500 trip reports have been transmitted over the past year fishing year. Most fishers are using FLDRS software, developed by the National Marine Fisheries Service, while there are 3 fishers using Elog, a proprietary software from Ecotrust, Canada. While the initial project focus was groundfish fishers, we are now increasingly working with those that operate mainly in other fisheries in the region, because all holders of a groundfishing permit are required to submit a vessel trip report, electronic or otherwise. In a further development, we are working with fishers in an electronic monitoring project that involves the addition of deck cameras. The goal of the project is to understand the potential application of cameras on ground fishing vessels (trawlers and other), including an ability to identify discards by species and number, and to develop protocols related to camera placement, operation, data collection, and video evaluation, that reduces monitoring costs to fishers and satisfies the reporting needs of NMFA and other stakeholders. This project currently involves 16 vessels in Maine, Massachusetts, and Rhode Island; video from 175 fishing trips and 550 hauls have been recorded to date.

Maine Inshore Acoustic Herring Survey

(Graham Sherwood, Adam Baukus, Curt Brown - GMRI, Mike Jech -NMFS)

This industry based collaborative effort utilizes ten lobster boats to perform an acoustic survey targeting herring in the coastal Maine waters. There are strong economic ties between the herring and lobster industries, through the supply of fresh and affordable bait. This incentive, combined with the globally recognized conservation ethic of the Maine lobster industry has engaged project participants to collect data that addresses gaps in the herring stock assessment. Each vessel is fitted with a scientific echosounder and conducts weekly transects (60-mile survey per boat) from September to November. We have currently analysed over 4200 miles of acoustic data from coastal waters that are inaccessible to larger federal survey vessels. The first year's data suggests the timing and duration of herring spawning may be more variable than previously thought, with direct implications for the current management scheme of spawning closures. Potential trends between management quotas and yearly biomass variations are being further explored. This project leverages funds from multiple sources to maintain the momentum of industry participation and a community-based approach to responsible ecological and economic stewardship of Maine and New England's herring resource.

Maine Inshore Acoustic Survey for Northern Shrimp

(Graham Sherwood, Adam Baukus, Julian Chawarski-GMRI)

This industry based acoustic survey utilizes the existing framework of a collaborative herring survey to focus on a new target species in a different season. The winter inshore migration of northern shrimp is monitored by 10 lobster vessels completing 40nm acoustic transects using a multifrequency transducer. The surveys are completed once a month from January through March. Extensive ground-truth sampling is used to verify the presence of shrimp in the acoustic data. Survey participants use traps and small trawlnets to capture shrimp, in addition to a larger trawl vessel using a full size commercial trawl, camera gear, and novel water sampling to analyse environmental DNA for presence and abundance of shrimp. Collaboration with the federal shrimp survey vessel including the installation of an identical transducer will further the use of acoustic data in shrimp management. Insight gained about biomass and distribution patterns from this project are very timely given the commercial fishery has been in moratorium since 2014, and very little information about the stock is currently collected. This two-year pilot project was funded through the Saltonstall-Kennedy program.

11.6.5 FishNext Research LLC, Mountlake Terrace, Washington

Craig S. Rose (fishnextresearch@gmail.com)

Satellite-reporting accelerometer tags to monitor survival of trawler deck-released halibut

Under existing catch handling regulations for Bering Sea trawl fisheries, trawl-caught halibut cannot be released prior to observer sampling in vessels' fish processing factories. The resulting delayed release produces high halibut discard mortality rates. In response, trawlers are working with NMFS to develop methods to quickly sort and release halibut from catches on deck, while accounting for their numbers, size, and viability. To evaluate expedited release efforts, information on the survival of released halibut is needed. A project, funded by the North Pacific Research Board and NOAA's SK Program applied satellite-reporting tags to observe survival outcomes of released halibut. We worked with Wildlife Computers to develop particular activity recording metrics for the Halibut-sPAT tag. These tags reported summarized accelerometer data to monitor halibut survival by tracking fish activity behaviors. Trawl taken as bycatch halibut are smaller than halibut previously studied with satellite tags, raising concerns that tags could affect halibut performance and survival.

In summer 2016, one hundred and sixty halibut were tagged with Halibut-sPAT tags during deck release from three trawlers targeting flatfish in the Bering Sea. Tags reported two-hour summary values of the number of rapid increases in tag tilt (swim starts) and the percentage of time tags tilted beyond a prespecified threshold (swimming %) while attached for up to 60 days. Ten longline-caught halibut selected to be in excellent condition were tagged to characterize 'natural' fish activity. We also tagged 6 seabed anchors and 4 halibut carcasses, providing sedentary or carcass-based tag metrics. Data patterns from these reference tag sets provided context for survival interpretation of tag data from trawl releases. Preliminary results from 2016 deployments indicated a strong relationship between survival and both time-on-deck and viability assessments, although halibut released during one trip had much lower survival than those from the other two trips. Satellite-tagging with accelerometer data can be an effective method to evaluate release survival for an important flatfish species with frequently sedentary behavior.

Automated measurement of halibut catch to allow bycatch reduction by Alaska groundfish trawl fisheries

Halibut bycatch limits significantly constrain groundfish trawl fisheries in Alaska waters. Bycatch is monitored based on the proportion of halibut appearing in catch samples taken by on-board observers extrapolated to unsampled portions of those catches, as well as to catches from unsampled tows and unobserved trips. Improving the precision and timeliness of halibut bycatch data would facilitate both bycatch tracking for management and the efforts of the fishing fleet to reduce or avoid halibut bycatch. With funding from NOAA's Bycatch Reduction Engineering Program, we worked with the Electronic Monitoring Innovation Group at the Alaska Fisheries Science Center and the Information Processing Lab of the Department of Electrical Engineering, the University of Washington, to develop, test, and improve a camera chute system that automatically images, measures and reports halibut numbers and weight at the conclusion of catch sorting. Systems include imaging, lighting, triggering, background needed to obtain image data to support software and processing system analyses to produce valid measurements and estimated weight. A range of advanced algorithms have been developed to separate halibut from backgrounds (segmentation). Extensive at-sea testing has motivated improvements to assure consistent operation in the challenging and varied environments encountered onboard Alaska trawlers fishing the Gulf of Alaska and Bering Sea.

11.6.6 Pacific States Marine Fisheries Commission (PSMFC) – Pacific Fisheries Bycatch Program, Newport, Oregon

Mark J.M. Lomeli (mlomeli@psmfc.org;http://www.psmfc.org/bycatch/)

Improving catch utilization in the US West Coast groundfish bottom-trawl fishery: An evaluation of T90 mesh and diamond mesh codends

Mark J.M. Lomeli (PSMFC), Owen S. Hamel (NMFS- Northwest Fisheries Science Center (NWFSC), Seattle, WA), W. Waldo Wakefield (NMFS-NWFSC, Newport, OR) and Daniel L. Erickson (Ocean Associates, Inc., Seattle, WA)

The US West Coast limited entry groundfish bottom-trawl fishery operates under a catch share program, implemented with the intention of improving the economic efficiency of the fishery, maximizing fishing opportunities, and minimizing bycatch. However, stocks with low harvest guidelines have limited fishers's ability to maximize catch of more abundant stocks. Size-selection characteristics of 114 mm and 140 mm T90 mesh, and traditional 114 mm diamond mesh codends were examined using the covered codend method. Selection curves and mean L_{50} values for two flatfish species (rex sole, and Dover sole), and two roundfish species (shortspine thornyhead, and sablefish) were estimated. Mean L_{50} values were smaller for flatfish, but larger for roundfish in the 114 mm T90 codend compared to the diamond codend. The 140 mm T90 codend showed significantly different selectivities from the other codends for rex sole, Dover sole, and shortspine thornyhead, being most effective at reducing the catch of smaller-sized fish, however with a considerable loss of larger-sized marketable fish. Findings suggest T90 codends have potential to improve catch utilization in this multispecies fishery. Funding for this study was provided by NOAA NMFS Bycatch Reduction Engineering Program.

Testing of two selective flatfish sorting grid bycatch reduction devices in the US West Coast groundfish bottom-trawl fishery

Mark J.M. Lomeli (PSMFC) and W. Waldo Wakefield (NMFS-NWFSC)

In the US West Coast limited entry (LE) groundfish bottom-trawl fishery, catches of constraining species (e.g. rockfish, sablefish, Pacific halibut) continue to hinder some fishers's ability to maximize catches of more abundant flatfish stocks (e.g. Dover sole, petrale sole). In this study, the size-selection characteristics of two flexible sorting grid bycatch reduction devices (BRDs), termed BRD-1 (6.4 x 25.4 cm grid size) and BRD-2 (6.4 x 30.5 cm grid size), designed to retain flatfish while reducing catches of rockfish, other roundfish, and Pacific halibut were evaluated using a recapture net. The size selectivity parameters for rockfish, other roundfish, and Pacific halibut did not differ significantly between the two designs. The size-selection characteristics between BRD-1 and -2 did not differ significantly for English sole or rex sole. However, for arrowtooth flounder 53–58 cm in total length (TL), Dover sole 39–53 cm TL, and petrale sole 36–49 cm TL, BRD-1 retained significantly more fish of these length classes than BRD-2. Combined, the mean flatfish retention (not including Pacific halibut) was 89.3% for BRD-1 and 81.7% for BRD-2. Compared to previous flatfish sorting grid selectivity work conducted in the LE groundfish bottom-trawl fishery, BRD-1 enhanced the retention of flatfish while substantially reducing catches of non-target species. Funding for this study was provided by NOAA NMFS Saltonstall-Kennedy Competitive Research Program.

Illuminating the headrope of a selective flatfish trawl: Effect on catches of groundfish and Pacific halibut

Mark J.M. Lomeli (PSMFC) and W. Waldo Wakefield (NMFS-NWFSC)

This study evaluated how illuminating the headrope of a selective flatfish trawl could affect catches of groundfish and Pacific halibut in the US West Coast limited entry groundfish bottom-trawl fishery. Lindgren-Pitman LED Electralume® fishing lights (color = green) were used to illuminate the headrope. Lights were grouped into clusters of three, with each cluster attached ca. 1.35 m apart along the 40.3 m long headrope. Using an alternate tow randomized block design, catch comparisons and ratios were compared between tows conducted with (*treatment*) and without (*control*) LED lights attached along the trawl headrope. Catches of rex sole, arrowtooth flounder, greenstriped rockfish, and lingcod were fewer in the *treatment* compared to the *control* trawl, however, not at a significant level. Bycatch of Pacific halibut was substantially different between the two trawls, with the *treatment* trawl catching an average of 57% less Pacific halibut. As for Dover sole and sablefish, significantly fewer fish were caught in the *treatment* than the *control* trawl. Compared to the *control*, the *treatment* trawl on average caught more rockfish (with the exception of greenstriped rockfish), English sole, and petrale sole, but not at a significant level. Findings show that illuminating the headrope of the selective flatfish trawl can affect the catch comparisons and ratios of several groundfish species and Pacific halibut and depending on the target or avoidance species, the effect can be positive or negative. Funding for this study was provided by NOAA NMFS Bycatch Reduction Engineering Program.

Further testing of LED lights as a technique to reduce bycatch in the ocean shrimp trawl fishery

Mark J.M. Lomeli (PSMFC), Scott D. Groth (Oregon Department of Wildlife, Charleston, OR) and W. Waldo Wakefield (NMFS-NWFSC)

The use of sorting grid bycatch reduction devices (BRDs) has substantially reduced fish bycatch in the ocean shrimp trawl fishery. However, bycatch of eulachon (an ESA threatened species) and darkblotched rockfish (a rebuilding stock) are still a concern. In 2014, PSMFC, Oregon Department of Fish and Wildlife, and ocean shrimp fishers tested how attaching 10 green LED lights to the central 40% of the trawl fishing line could alter eulachon and darkblotched rockfish bycatch. Results were successful with eulachon and darkblotched rockfish catches being reduced by 91% and 82% by weight, respectively, while maintaining ocean shrimp catches. While positive results were achieved, scientific questions remain as to how fish bycatch and ocean shrimp catches are affected by the 1) number of lights attached in the central portion of the trawl fishing line, and 2) use of lights along the fishing line of the trawl wings. With the potential of management to require the use of lights along ocean shrimp trawl fishing lines, better understanding how lights influence bycatch in this fishery is extremely important. This upcoming 2017 research will further test the use of LED lights and determine how catches of eulachon, darkblotched rockfish, and ocean shrimp are affected by 1) altering the number of lights attached along the central portion of the trawl fishing line, and 2) attaching lights along the fishing line of the trawl wings as opposed to the central portion. Lindgren-Pitman LED Electralume® fishing lights (color = green) will be used in the experiments. Results are anticipated to provide management and industry with information on how light attached along a trawl's fishing line can influence bycatch in the ocean shrimp trawl fishery. Funding for this study was provided by NOAA NMFS Saltonstall-Kennedy Competitive Research Program.

Artificial light: Its effect on the overall escapement of Chinook salmon out a bycatch reduction device

Mark J.M. Lomeli (PSMFC) and W. Waldo Wakefield (NMFS-NWFSC)

The Pacific hake fishery represents the largest groundfish fishery by volume off the US west coast. Although landed catches consist of mostly hake, bycatch of Chinook salmon, a prohibited take species with nine ESA listed ESUs, is an issue affecting the fishery. Hence, developing techniques that minimize Chinook salmon bycatch are important to fishers, management, and the recovery of ESA listed salmon. In 2015, the PSMFC, NMFS-NWFSC, and Pacific hake fishers tested if artificial illumination could influence which escape window (4 windows available) Chinook salmon utilize when exiting a bycatch reduction device (BRD). The data showed that illumination significantly influenced ($p < 0.00001$) where they exited out the BRD, but also indicated that illumination could be used to enhance their escapement overall. However, further study is necessary to determine if illumination can improve Chinook salmon escapement. This upcoming 2017 study will determine the effect that artificial illumination has on Chinook salmon bycatch by comparing their escapement rates out a BRD between tows conducted with and without the use of artificial illumination. Lindgren-Pitman LED Electralume® fishing lights (color = blue) will be used in the experiments. Escapement rates will be quantified using a recapture net. Results from this study are anticipated to show that artificial illumination can be used as a technique to enhance Chinook salmon escapement. Funding for this study was provided by NOAA NMFS Bycatch Reduction Engineering Program.

11.6.7 NOAA Fisheries, Alaska Fisheries Science Center (AFSC), Conservation Engineering Group, Seattle, Washington

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Halibut Excluders-RACE MACE Conservation Engineering

In 2016, CE scientists, in collaboration with a Bycatch Reduction Engineering Program (BREP) project led by FishNext Research (Craig Rose), executed a cooperative fishing gear research charter on the F/V *Marathon* in the Gulf of Alaska to test the use of selective herding lines in front of the trawl footrope as a bycatch reduction device for halibut. The hope was that this bycatch reduction device (BRD) would separate halibut from target species in the mouth of the net, as opposed to just in front of the codend, where most current BRD's are located. This excluder concept is based on CE observations that show halibut swimming ahead of the trawl for longer periods than smaller flatfish. The purpose of the selective herding lines is to allow halibut to escape over the wing extensions before they enter the trawl, causing less stress on escaping fish compared to an excluder just forward of the codend.

Thorough video analysis is still needed but initial findings from fishing tows conducted with a closed codend encountered poor fishing production. There could be several reasons for low fishing productivity, including 1) low density of target species during the experiment, 2) while the selective herding lines seemingly encouraged halibut to escape over the wings, they may have also increased escape of target species, and 3) poor water quality/visibility. While plenty of halibut were encountered, the mixture of trawl-catchable fish species was different from expected. Fewer small soles were caught, replaced by more pollock, arrowtooth flounder and rockfish.

Develop alternative trawl designs to effectively capture pollock concentrated against the seafloor while reducing bycatch and damage to benthic fauna

The Alaska pollock fishery requires the use of pelagic trawls for all tows targeting that species. During some periods of the pollock fishery, these fish concentrate against the seabed and, to capture them, fishers have to put nets designed for midwater capture onto the seabed. We are developing footropes raised slightly off of the seabed in order to have less effect on seabed habitats than the continuous, heavy footropes (generally chains) currently required on pelagic trawls. We have held several workshops with 20+ participants, including captains of pollock trawlers and industry representatives, as well as federal and university scientists to come up with ideas for alternative footropes to test. In May 2014 we began exploring these possibilities with experiments to compare the seabed effects of the different alternative footropes. Preliminary results show that we reduced footrope contact with the seabed by at least 90%. This research was funded through an award to NOAA-AFSC and Alaska Pacific University (APU) from the North Pacific Research Board and the final report of that project is now available on the web (http://projects.nprb.org/#metadata/01f771ea-b802-41cb-b468-281ab28c8475/project). In order to better understand benthic habitat effects of current pollock trawl footropes, collaborators from Alaska Pacific University will join a 2017 research cruise with the Conservation Engineering group. They will examine how the bottom contact varies along the chain footropes used by the pollock fishery under different deployment conditions.

Provide underwater video systems to fishers and other researchers to facilitate development of fishing gear improvements

We have continued to provide underwater video systems to be used by the fishing industry to allow them to directly evaluate their own modifications to fishing gear. Beyond their direct use, exposure to NMFS systems has motivated many companies to procure similar systems for dedicated use on their vessels. Either way, the goal of better understanding of fishing gear operation and quicker development of improvements is being realized. The current systems have been in use for about 5 years now and have proven to be very easy to use, durable and flexible. All camera system components are enclosed in a single 8.9 cm (3.5 inch) diameter acrylic tube mounted on a plastic plate. The entire system measures 53.3 x 22.9 x 12.7 cm (21 x 9 x 5 inches) and is of nearly neutral buoyancy in water. The Conservation Engineering group now has six of these systems for both our use and for use as loaner systems. While this design is so inexpensive and functional that many vessels have acquired their own systems, there is still a need for loaner systems. In 2016, we ruggedized the existing loaner camera system design by replacing the acrylic tube with a titanium tube. This new system was successfully field tested through our loaner camera program. Representatives from the pollock fishery used four loaner cameras (one of which was the new ruggedized system) in 2016 to do their own field tests to examine if the use of light on existing salmon excluders could enhance salmon escapement during fishing.

11.7 Denmark

11.7.1 Danish Technical University (DTU AQUA)

Industry led gear selectivity improvements, its strengths and weaknesses under the new Common Fisheries Policy (CFP).

Contact: Tiago Malta (timat@aqua.dtu.dk)

The project will test gear selectivity solutions developed by the industry with the objective of solving the arising issues faced under the new CFP landing obligation system. First, we determine through the use of stochastic simulation the minimum number of individuals needing to be measured in order to allow us to correctly assess the performance of the new gear in relation to the standard one. Second, we use that knowledge and advise the fishers on the size of samples needing to be collected by them. In the following months several fishers participating in the project will be collecting and providing us length based data on the performance of their new gears.

During this period, the data provided will be analysed and feedback will be given to the fishers. Finally, when both fishers and scientists are satisfied with the performance of the gear, a full scientific trial will be performed.

Fast-Track – Sustainable, cost-effective and flexible gear solutions under a landing obligation

Contact: Jordan Feekings (jpfe@aqua.dtu.dk)

The project aims to establish a platform comprised of stakeholders (fishers, netmakers, producer organizations, managers and scientists) with the intention to promote the development of ideas and solutions originating in the industry. Furthermore, the project aims to facilitate and fast track the testing of new designs proposed by stakeholders and their implementation in legislation.

With the reform of the EU Common Fisheries Policy and the introduction of a Landing Obligation the ability of fishers to adjust the selectivity of their gears to suit the quotas which are available to them will be an important factor in determining the revenue and rentability in the fishery. As the combination of gear, fishing practice and quota shares will differ between vessels, changes to the selectivity of the gears will need to be implemented at the vessel level and based on the quotas which are available to the vessel at a given time. For this to be realized, simple and cost-effective solutions which can be quickly coupled with existing gears will be in demand. These solutions will need to be implemented quickly in order for them to solve the issues at hand without losing substantial income. Furthermore, these solutions will need to be scientifically tested to document their effect before being considered for implementation into the legislation.

To date, there are 5 selectivity trials being carried out in the project; 2 in the *Nephrops* directed fisheries, 2 in the Baltic cod fishery, and 1 in the North Sea beam trawl fishery for brown shrimp. A description of the project as well as the work being carried out in the project can be found on the project home page: www.fast-track.dk

Review on programs established to encourage industry-led approaches to selective gear development

Contact: Jordan Feekings (jpfe@aqua.dtu.dk)

DTU Aqua has compiled a review on programs established to encourage industry-led approaches to selective gear development (e.g. Cefas – The 'Clean Fishing' competition, DTU Aqua's MINIDISC project providing fishers with free gear choice, WWF smart gear competition). The idea is that such collaborative projects (a bottom up approach) have a better success rate of implementing selective gears as opposed to a top down approach where selective gears are enforced into legislation and the selective performance of these gears negated. We also propose a framework on how to evaluate collaborative research projects based on 4 main criteria: economic, social, scientific and management.

Danish seine – Ecosystem effects of fishing

Contact: Thomas Noack (thno@aqua.dtu.dk)

Since the amount of scientific studies on Danish seining is rather low, the study "Danish seine – Ecosystem effects of fishing" has been initiated in 2013. The study included several experiments in order to increase the knowledge of Danish seining, its impacts on the environment and to give advices to potentially improve selectivity characteristics and efficiency of the gear. We conducted a fishing profile comparison to bottom trawls based on a perennial observer dataset and carried out two sets of experimental trials on commercial vessels. The first set in 2014 looked at codend selectivity as well as the escapement behavior of fish and invertebrates from other gear parts. The second set of trials in 2015 allowed us to create detailed descriptions of the fishing process through geometry and forces acting between net and ropes and furthermore, to evaluate the behavior of fish in relation to the gear and to evaluate impacts of the gear on the seabed.

Identifying simple and cost-effective gear solutions which can lead to an effective implementation of the new EU common Fisheries Policy (CFP)

Contact: Valentina Melli, PhD student (vmel@aqua.dtu.dk)

The new EU common Fisheries Policy (CFP) introduced a landing obligation for all the main commercial species. Consequently, it is now in fishers' interest to improve gears selectivity in terms of both size and species composition. Many of the bycatch reduction devices already tested are not flexible enough to match the highly variable fishing process, in particular in the mix-species trawl fishery. Thus, with this project, we aim at producing a set of different solutions that can improve gears selectivity on a haul by haul level. To reach this goal, we combine current knowledge in fish ecology and fish behaviour with gears technologies to produce simple and flexible bycatch reduction devices, easy to mount and de-mount on the gear. We work on the gear design at different levels, by either preventing species entrance in the net (FLEXSELECT project) or by leading them into different compartments (VISION project).

Gear technical contributions to an Ecosystem Approach in the Danish set-nets fisheries

Contact: Esther Savina, PhD student (esav@aqua.dtu.dk)

Although the fleet has reduced since the mid-1990s, Danish gill- and trammelnets are still of importance and are likely to gain increasing interest as environmentally friendly practices. However, such a development may only happen if the ecosystem approach is guaranteed. There is limited knowledge of ecosystem impacts, such as for example physical damage to habitats or discards, and their minimization may require development of alternative practices. With regard to the upcoming challenges of an Ecosystem Approach to Fisheries, the project aims at (1) studying the sweeping behaviour of nets and their effect on the seabed; (2) quantifying invertebrates and fish discards and understanding how the capture process can influence discard behaviour; (3) developing technical innovation that could improve catch quality and therefore maximize the production. Trials are conducted on gill- and trammelnets within the Danish coastal waters. This is a PhD run as part of the Skånfisk project financed by the Ministry of Food, Agriculture and Fisheries of Denmark.

Test and development of an Excluder system in the Danish industrial fishery for Norway pout.

Contact: Ludvig A. Krag (lak@aqua.dtu.dk)

The project aims at testing and further developing the Excluder system for Danish trawl fisheries. The Excluder system is used on a voluntary basis in the flatfish fisheries in Alaska today and the system's design principals have a potential to improve both the size and species selectivity in several fisheries in EU waters. The Excluder system needs however to be modified and tailored for these fisheries. The system will initially be tested in the industrial fishery for Norway pout where there is bycatch of gadoid species and herring. With the landing obligation system, which is introduced into the EU waters under the new Common Fisheries Policy there is a great need for selective systems that can improve the fishers' ability to improve both species and size selectivity. The project is made in collaboration with the Pelagic Fishers's Association, TORMO trawl and SINTEF Hirtshals.

Establishing a morphology based predictive sizes selectivity model for sole (*Solea solea*) for towed gears

Contact: Ludvig A. Krag (lak@aqua.dtu.dk)

Sole is an important commercial species in Danish and EU waters, but little work is done in size selectivity in different mesh sizes and trawl designs. The project will establish a morphology-based predictive model for size selectivity using the FISHSELECT methodology. Covered-codend experiments will be conducted in the sole trawl fishery to establish experimental selectivity data for sole to evaluate the predictive model. The project will deliver design guides predicting size selectivity for sole in relevant mesh sizes and shapes. Further sole's contact likelihood with mandatory selective devices will be estimated.

Developing and introducing small-scale Danish seine technology in the Baltic Sea fishery

Contact: Ludvig A. Krag (lak@aqua.dtu.dk)

The Baltic Sea gillnet fishery is challenged due to an increasing population of grey seals. The seals steal the entangled catch or damage the caught fish to an extent where they have no commercial value. Catch from other passive gears like hooks or longlines are similarly damaged by the seals. Small-scale Danish Seines systems, currently used in Swedish waters will be transferred to Danish gillnetting vessels to evaluate the economic and operational potential in the Baltic Sea cod and salmon fishery. The project is part of a larger focus on testing and developing fishing methods or tactics that can secure an economical viable fishery in the Baltic under an expanding seal population.

Enhancing gear selectivity, catch value and handling by the use of innovative gear solutions and fish behavior

Contact: Junita D. Karlsen (jka@aqua.dtu.dk)

In the project FishValue a horizontally divided codend showed prospects of increasing the income in the Danish mixed fishery by improving the quality of fish as well as providing differentiated size selection in upper and lower compartments while retaining valuable catch. Successful separation of fish and organisms with hard and spiny outer surfaces led to significant improvements of several quality parameters of whole fish, fillets and *Nephrops* in several steps of the value chain. However, a large proportion of cod, hake and flatfish entered the small mesh lower compartment from which they were unable to escape from through mesh penetration. Based on the large interest in the gear design from the industry the following-up project VISION explores ways of increasing the proportion of fish entering the upper compartment without compromising the catch of *Nephrops*. Main focus is on solutions involving light and/or new netting types aiming at guiding fish into the desired locations of the gear, but mechanical solutions appearing as barriers to preventing the fish from entering the lower compartment, or to stimulating fish to enter the upper compartment are also included.

Discard survival in relation to the landing obligation under the new European Common Fisheries Policy

Contact: Junita D. Karlsen (jka@aqua.dtu.dk)

The new European Common Fisheries Policy (CFP) has introduced substantial change to fisheries management, including a phased introduction of an obligation to land all catches taken from regulated stocks. However, the article 15 paragraph 4b of the CFP regulation (EU) No 1380/2013, allows for the possibility of returning at sea species for which 'scientific evidence demonstrates high survival rates'. Such exemptions aim at reducing the risk under the European landing obligation of bringing onshore individuals that may otherwise survive the capture-and-discard process. Flatfish have been identified as potential candidates for such exemptions. In the COPE-project, a catalogue of survival rates of different species subject to the landing obligation based on information provided by the scientific literature and new assessment of a selected species for the Danish seine and trawl fisheries in the North Sea or Skagerrak area. Reflex and injury assessments are used to identify reflex action mortality predictors (RAMPs), which, in combination with analysis of physiological stress indicators, will be used in to obtain survival estimates. The aim is then to use the identified RAMP's in a fisher self-sampling program to provide survival estimates covering a range of fishing practices within the fleet.

11.8 Sweden

11.8.1 Swedish University of Agricultural Sciences - Department of Aquatic Resources

Contact: Hans Nilsson (hans.nilsson@slu.se), Daniel Valentinsson, Johan Lövgren, Andreas Sundelöf, Sven-Gunnar Lunneryd, Peter Ljungberg and Sara Königson. http://www.slu.se/institutioner/akvatiska-resurser/selektivt-fiske/ (in Swedish)

A Secretariat (Secretariat for selective fishery) at SLU was established 2013, to help the fishery to implement the new Common Fishery Policy (CFP), with special focus on the landing obligation.

This secretariat main task´s is to collect ideas from the industry, making project out of them and after development test them scientifically. The secretariat is founded by the Swedish Agency for Marine and Water Management and is a four-year commitment from the government. Focus areas are divided between active and passive (new fisheries).

Project 2016 (one year projects)

- Saithe grid (active, large-scale pelagic fishery, Andreas Sundelöf)
- Cod trap (passive, Sven-Gunnar Lunneryd)

Project 2016 to 2017 (two year projects)

- Combined pot fishery cod and flatfish (passive, Sven-Gunnar Lunneryd)
- Mackerel pushup trap (passive, Sven-Gunnar Lunneryd)
- Seal safe combined pots (passive, Sven-Gunnar Lunneryd)
- Cod and flatfish trawl (active, two codend trawl divided by a grid, Johan Lövgren and Hans Nilsson)
- Shrimp trawl (active, species and size selective grid, Daniel Valentinsson)
- Size selectivity in small shrimp trawlers (active, Daniel Valentinsson)
- Baltic cod trawl fishery – new T90 design (active, Hans Nilsson)
- Topless trawl – Nephrops fishery (active, Johan Lövgren and Hans Nilsson)
- Baltic cod trawl fishery – multiple selective devices (active, Hans Nilsson)

- Shrimp pots (passive, Peter Ljungberg)
- Ergonomic push-up trap (passive, Sven-Gunnar Lunneryd)
- Seal safe trap fishery after Herring (passive, Sara Königson)

Project 2017 (on year projects)

- Seal safe trap fishery after flatfish (passive, Sven-Gunnar Lunneryd)
- Seal safe trap fishery after cod (passive, Sven-Gunnar Lunneryd)
- Trouser trawl Cod/Saithe and Haddock (not decided, active, Hans Nilsson)
- Selectivity in legal codends Skagerrak and Kattegat (not decided, active, Daniel Valentinsson)
- Seal safe trap fishery after cod (not decided, passive, Sara Königson)

11.9 Ireland

BIM's work in 2016 focused on evaluating technical measures to improve gear selectivity and address the landing obligation. Three gears were tested in the multi-rig *Nephrops* fishery and one in the multi-rig whitefish fishery.

Assessment of square mesh codends in an Irish Nephrops fishery

The catches of three 4-panel square mesh codends with nominal mesh sizes of 45, 55, and 65 mm were compared with a standard 2-panel 75 mm diamond mesh codend using quad-rigged *Nephrops* trawls. The 45 mm square mesh codend performed the in terms of reducing undersize (<25 mm) and retaining marketable *Nephrops*. Losses of marketable *Nephrops* were high in the 55 and 65 mm square mesh codends though they performed best in reducing catches of undersize *Nephrops*, haddock and whiting. Report is available on the BIM website at: https://tinyurl.com/ktbjmcu.

Assessment of T90 mesh in a fishery targeting whiting

Catches from an 80 mm (nominal) mesh size T90 codend and extension piece were compared with a standard 80 mm diamond mesh codend and extension piece using twin rigged whitefish trawls. In the T90 gear there were substantial reductions of whiting below the market sized (32 cm) and increases in catches of marketable haddock, whiting and plaice. An additional benefit was the increased quality of the catch observed in the T90 gear. Report is available on the BIM website at: https://tinyurl.com/k4ug9ww.

Assessment of a dual codend with net separator panel in an Irish Nephrops fishery

Catches from this Mike Montgomerie (SEAFISH UK) designed gear (see pic) were compared with a standard 80 mm (nominal) extension piece and codend. Substantial reductions in catches of undersized (30 cm) haddock and below market sized(32 cm) whiting were observed using the test gear. Report is available on the BIM website at: https://tinyurl.com/lulhv9e.

Assessment of SELTRA sorting box in an Irish Nephrops fishery

Catches from a 70 mm (nominal) diamond mesh codend fitted with a 300 mm SELTRA sorting panel were compared with a standard 70 mm codend fitted with a 300 mm square mesh panel 9 m from the codline. Substantial reductions in fish catches were observed in the SELTRA compared with the standard 300 mm square mesh panel e.g. 24% of whiting, 51% of haddock, 81% of cod and 74% of dogfish. *Nephrops* catches were improved by 19% in the SELTRA compared with the standard 300 mm panel. Report is available on the BIM website at: https://tinyurl.com/BIM-SELTRA.

BIM's work in 2017 will continue to be focused on evaluating technical measures to improve gear selectivity and address the landing obligation.

Some of the gears/ modifications identified for evaluation are:

- Raised fishing line in a fishery targeting whiting to reduce catches of cod
- Measures to improve performance of the SELTRA 300 sorting box through active stimulation
- Further testing of T90 80 mm codend and extension piece/ square mesh panel
- Further work to improve Nephrops separation in the dual codend with net separator panel
- *Nephrops* survivability study using highly selective gear in trawl fishery

11.10 Netherlands

11.10.1 Institute: Wageningen Marine Research, ILVO

Contacts: Pieke Molenaar (pieke.molenaar@wur.nl); Edward Schram (edward.schram@wur.nl).

Project: Survival of discarded flatfish and rays and how to improve it

In the light of the implementation of the European Landing Obligation survival chances after discarding in the Dutch demersal fleet were studied for Sole, Dab and Plaice. This follow-up project is focusing exclusively on survival chances of discarded fish in the Dutch commercial pulse fisheries. In 2017 nine observer trips are planned on 3 pulse trawlers. The main objective of this project focuses on promoting survival chances of discarded fish by (i) adjustments in the on-board catch processing and (ii) trawl and trawling modifications. To explore the potential of the modifications Plaice is chosen to be the indicator species. The effectivity will be first measured trough vitality self-sampling by fishers, flowed by a scientific observer trip with Wageningen Marine Research observers. The secondary objective of this project is to collect additional data for species with limited survival data. Data on survival chances for turbot, brill, sole and rays will be collected during normal commercial catch and processing circumstances. All sampled fish will be scored for external damages and reflex impairment, then tagged to allow individual monitoring over 21 days in captive observation.

11.10.2 Institute: Wageningen Marine Research, Thünen Institute

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Project: Improving and understanding SepNep performance

Achieving an efficient species and size selection for both the target and the bycatch species is a feature of increasing demand in Europe due to the landing obligation (LO)(part of the Common Fisheries Policy (CFP) reform (EU1380/2013)). This LO was introduced in the European Nephrops fisheries from 2016 onwards.

SepNep (Figure 11.10.1) is a sorting device for Norway lobster (*Nephrops norvegius*) fisheries. The concept is based on the separation of fish and *Nephrops* in two codends in a modified trawl that is mounted with a sieve panel. To provide an efficient *Nephrops* selectivity the SepNep trawl was supplemented with an innovative grid, mounted in the front part of the lower codend (the *Nephrops* codend). The device was first developed and tested during a cooperative research project by a former fisher during a bottom–up industry-science project. After this project, the gear was further optimized in 2016. At the ICES-FAO WGFTFB annual meeting, Dutch and German researchers agreed on a collaborative research cruise together with fishers to obtain fundamental knowledge of SepNep selective properties and improve its performance. The research cruise was conducted on 8–22 September in 2016.

For the research cruise a commercial *Nephrops* trawl was designed, a third codend was attached to the rear of the grid to measure fish and *Nephrops* passing through, which would escape in commercial operations. All three codends were constructed of small mesh (50 mm) to retain the separated fractions of the catch. While fishing on Dutch and German *Nephrops* grounds, four SepNep designs were tested on RV Solea. SepNep1 and 2 were considered successful and tested for multiple hauls.

The SepNep 1 sorting panel sieved 80% of the marketable Nephrops to the lower codend. After improving its design, by lifting the panel, this was increased to 87% in SepNep2. The remaining *Nephrops* observed in the upper codend were mostly larger individuals. Modelled flatfish selection curves were strongly dependant on fish length, but most of the undersized individuals were guided to the upper codend. The results of the grid demonstrated a steep and precise size selection curve for *Nephrops*, a 19 mm bar spacing allowed 56% of the non-marketable *Nephrops* to pass.

Achieving optimal separation between *Nephrops* and fish species in trawls with multiple codends with different mesh sizes can dramatically reduce the bycatch in the *Nephrops* fishery. Additionally, the steep selection curve of the improved *Nephrops* grid offers various possibilities for commercial applications and can have positive effects on the stocks. The results demonstrate the potential for this SepNep concept and it may be a step forward in implementing and acceptance of the EU LO by the industry.

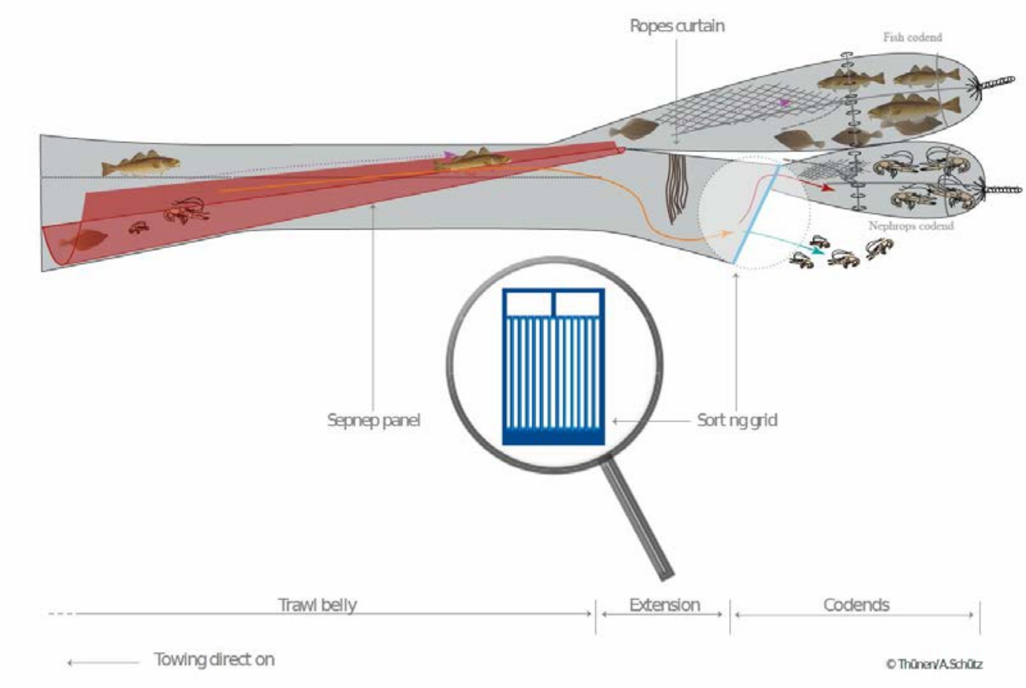

Figure 11.10.1. Commercial SepNep configuration. The separation panel (red) is guiding the large specimens of the catch to the large mesh upper codend. *Nephrops* is passing the mesh of the panel entering the lower codend. A gird is mounted in the front aft of the lower codend to mitigate catches of non-marketable *Nephrops*.

11.10.3 Institute: Wageningen Marine Research, ILVO

Contacts: Pieke Molenaar (pieke.molenaar@wur.nl); Josien Steenbergen (Josien.steenbergen@wur.nl), Maarten Soetaert (maarten.Soetaert@ilvo.vlaanderen.be)

Project: Trawl innovation in demersal fisheries 2

This follow-up project was initiated by the Dutch cooperation "De Nederlandse Vissersbond" to enhance gear selectivity and release as many undersized fish as possible in four Dutch fisheries as a reaction to the EU Landing Obligation on discards.

In 2017 innovative gear designs will be tested in the following fisheries: sole pulse trawl, plaice twin-rig, *Nephrops* quad-rig, and fly-shoot. Following the design phase a number of gear configurations were tied out on various commercial trawlers. Initial tests will be done using self-sampling protocols and underwater recordings, in many cases followed up by a detailed catch comparison with Wageningen Marine Research or ILVO scientists onboard.

For sole pulse fisheries trials are planned for a separation panel in front of the electrical stimulation to achieve preferred species separation. Two codends will be used to catch separated catch fractions. To reduce catches of benthic organisms trials are planned with the Electric Benthos Release Panel (eBRP) in a commercial vessel.

The *Nephrops* fishery is focusing on enhancing SepNep gear performance on commercial vessels on several aspects. Trials with alternative mesh shapes and escape panels are planned for 2017 to allow undersized flatfish to escape and retain marketable *Nephrops* in the large mesh codend. Grid position and bar spacing trials will be performed to further reduce catches of non-marketable *Nephrops*. Besides those developments the basic design will be tested on 13 commercial vessels.

11.10.4 Institute: Wageningen Marine Research

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Project: Alternative sieve net for Brown shrimp beam trawls

Dutch brown shrimp beam trawlers have the obligation to fish with a bycatch reducing device (Sieve-net) between April–November and all year round in certain areas. The Sieve-net can get clogged up very rapidly, especially in months where large macroalgae and jellyfish are abundant. This can lead to significant loss of marketable shrimp. Once clogged, it is difficult and time consuming to clean the Sieve-net for it to function properly again. A new device, that does not clog up rapidly or is easy to clean, is therefore desired by the industry.

This project focused on testing an alternative bycatch reducing device (Sieve-mat, Figure 11.10.2) in the Brown shrimp fishery. This device is mounted in front of the trawl entrance, only allowing shrimps and fish to enter the trawl trough the mesh of the Sieve-mat. Larger bycatch as fish and other organisms that are not able to pass the mesh size are forced to escape under the footrope. A scientific pilot study during one trip was conducted on the selective properties of the Sieve-mat when compared with the commercial used Sieve-net.

Figure 11.10.2. The Sieve-mat is placed in front of the trawl opening and attached to the footrope.

The results of this pilot trip indicated that on average the Sieve-mat caught 3% more catch overall, 41% more marketable shrimp, 14% more shrimp discard, 34% less non-target faunal bycatch and 78% less macroalgae. When splitting the non-target faunal bycatch into two groups it became clear that the Sieve-net caught 90% less benthic bycatch such as Common starfish (*Asterias ruben*) and *Ensis* Spp., but 74% more fish bycatch such as Herring (Clupea harengus) Goby (Pomatoschistus spp). When looking at the quantity of bycatch caught per Kg marketable shrimp the Sieve-mat caught 53% less non-target faunal bycatch, 92% less benthic bycatch and 23% more fish bycatch per Kg marketable shrimp caught. A statistically significant difference was observed in the catch of marketable shrimp, bycatch of fish and the bycatch of benthic fauna. Other variables were not statistically significant, regardless of some of the high differences observed.

The results of this pilot study are promising, multiple areas, and hauls need to be surveyed in future to further investigate the performance.

11.10.5 Institute: Wageningen Marine Research

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Project: Discard valves

The Dutch large cutter fleet operating in the North Sea consists of three segments: a beam trawl, twin-rig, and *Nephrops* fishery. Cutters within this fleet differ in vessel length overall (23–40 m), engine power (223–1491 kw), beam length (4–12 m), mesh size (70–>120 mm), haul duration (1.5–6 hours), catch quantity (up to 4000 kg per haul), and catch processing time (30–45 minutes). The high quantities of catches per haul can only be processed in an efficient way through semi-automatic sorting and processing machinery on board of the fishing vessels.

These high catch volumes subsequently result in high discard rates. The beam trawl fishery is responsible for the biggest quantity of discards. In the period of 2011–2013, an average of 56 000 tonnes per year were discarded. For the biggest beam trawl vessels discard rates reach up to 74%. These rates are exceptionally high and in the 'danger zone' where small uncertainties in the estimation have a disproportionately large effect on raised discard quantities.

In the Dutch discard monitoring programme the total catch volume per haul is estimated by the skipper and the scientific observer. There are several methods to quantify the catches of the cutter fleet in the North Sea. These methods and their pros and cons are presented in this paper. The total volume of discards from each haul is then calculated by subtracting the weighed total landings from the estimated catch volume.

Several of these methods are evaluated and analysis has shown that catch estimations vary substantially between methods. To prevent these inaccurate estimations a solution for the cutter fleet in the North Sea can be found in the use of automated discard valves. A solution to accurately weigh all the catch that would fall through the discard valves. The valves (Figure 11.10.3) are designed to fully automated measure quantities falling through the shaft. It opens and closed two separated programmed valves so that all fish, benthos and debris are measured in weight. The first prototype has been developed and tested.

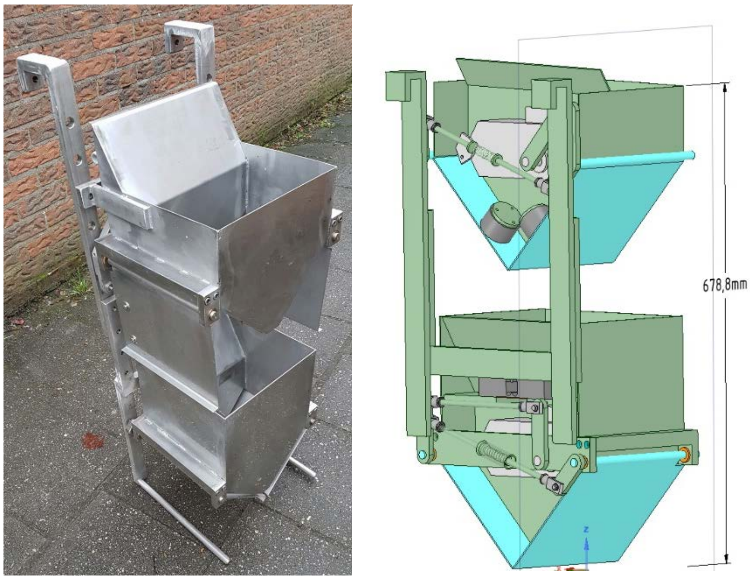

Figure 11.10.3. First prototype of the automated valve. The portable design is developed for accurate measuring of large discard volumes in semi-automatic catch processing.

11.10.6 Institute: Wageningen Marine Research

Contacts: Adriaan Rijnsdorp (adriaan.rijnsdorp@wur.nl), Pieke Molenaar (pieke.molenaar@wur.nl), Jan Jaap Poos (janjaap.poos@wur.nl)

Effects of electrical stimulation on the mesh selection of the sole pulse gear

Pulse trawls may improve the selectivity by reducing the proportion of undersized fish (van Marlen *et al.*, 2014). An experimental fishing trip was held on 18–22 July 2016 on board of pulse trawl vessel TX43 "Biem van der Vis" (SME17) to study the effect of pulse stimulation on the net selectivity (contact-selection curve) for the two target flatfish species. The commercial 80 mm codends were covered with a fine-meshed cover to collect the fish that escaped through the meshes. The effect of the electrical stimulation was tested by alternatingly switching off the electrical stimulation of the portside or starboard net.

Twenty-nine of the 35 valid hauls taken in the southern North Sea (4c, 4b) were analysed. Haul duration varied was around 2 hours. The weight of the catch in the cover and the codend was measured. The catch was processed on a conveyor belt. All individual sole and plaice (29 hauls) were picked up and their length distribution (cm-below) was determined. If the total number of fish exceeded 150 fish, a subsample was measured. Codend selectivity was estimated with a mixed effect model by fitting a logistic regression: ($n_{(cod\text{-}end)}/n_{cover} = \alpha+\beta L+\alpha_e+\beta_e L+\varepsilon_f+\varepsilon_r$)

with ncod-end is the number of fish of length L that is caught in the codend, ncover is the number of fish of length L that is caught in the cover, α is the intercept, α_e is the effect of electrical stimulation on the intercept, β is the slope of the logistic regression and β_e is the effect of electrical stimulation on the regression slope. ε_f is the normally distributed error tern $N(0,\delta)$ of the fixed effect (length) and $\epsilon_r$is the normally distributed term $N(0,\delta)$ of the random effect (haul).

Electrical stimulation increased the catch weight by 42% (95% cl = 39% – 46%). Table 11.10.1 presents the mean and standard deviation of the catch weight of the codend and cover of the electrically stimulated and reference net.

Table 11.10.1. Mean and standard deviation of the total catch weight (kg) and the codend and cover separately of the starboard and port side net with and without electrical stimulation.

	Total		Codend		Cover	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Port side						
Pulse	544	372	378	299	166	110
Reference	359	263	238	150	121	155
Starboard						
Pulse	528	276	324	127	204	176
Reference	396	341	236	227	159	150

Mesh selection was significantly affected by the catch weight of the net (both species). For sole, the mesh selection was also affected by the electrical stimulation (Figure 11.10.4). The results showed that the selection ogive for soles that were exposed to an electrical stimulus was steeper than for soles which were only mechanically stimulated. For the 80 mm codend, this implies that a larger proportion of the marketable sized sole (24 cm or more) will be retained in the pulse trawl. For the undersized sole, the retention percentage might be somewhat lower although the confidence limits of the fitted ogives overlap. For plaice, no effect of electrical stimulation on the mesh selection was observed.

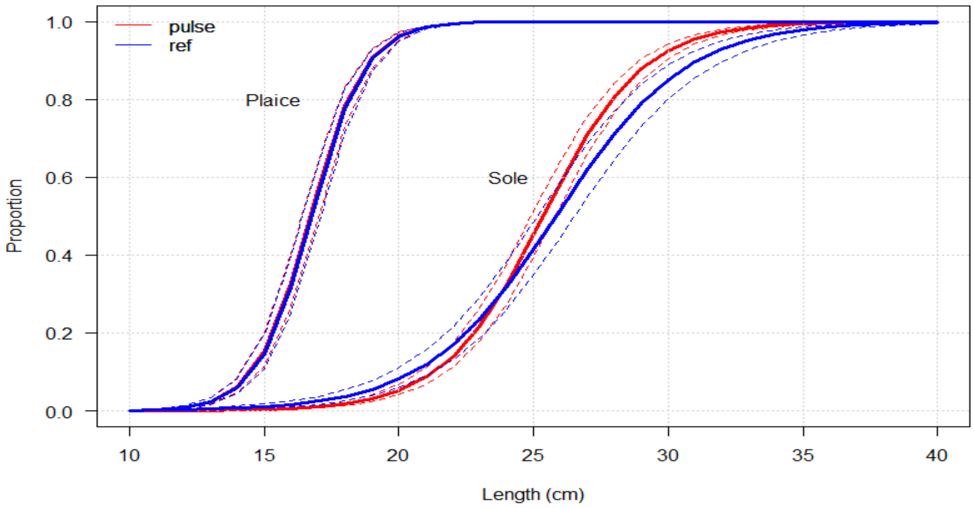

Figure 11.10.4. Selection ogives for sole and plaice for an 80 mm pulse trawl where the fish were exposed to electrical pulse stimulus (pulse) and the trawl where the pulse stimulation was switched off.

11.10.7 Institute: Wageningen Marine Research, Wageningen University, Netherlands Institute for Sea Research, ILVO

Contact: Adriaan Rijnsdorp (adriaan.rijnsdorp@wur.nl)

Pulse trawl impact assessment

In the North Sea an experimental fishery is currently taken place using electrical stimulation to catch sole. The vessels operate under a temporary derogation from the EU. Previous research indicated that pulse fishing may improve the selectivity reduce the ecological impacts (van Marlen *et al.*, 2014). However, there is widespread concern among stakeholders about possible detrimental effects. In order to provide the scientific basis for an assessment of the contribution of pulse fishing to a more sustainable fishery, a 4-year research project started in 2016.

The overall aim of this project is to assess the long-term impact of the commercial application of pulse trawls in the North Sea flatfish fishery. In order to fulfil the overall aim, predictive models of the effect of electric pulses on organisms and on different ecosystem components will be developed and applied. The results will be integrated to assess the consequences of a transition in the flatfish fishery from using tickler chain beam trawls to pulse trawls on the bycatch of undersized fish (discards) and the adverse impact on the North Sea ecosystem.

The research project comprises of four interrelated work packages and uses a variety of complementary approaches. In addition to these four work packages dedicated to the research (Figure 11.10.5).

WP1 will carry out laboratory experiments and develop predictive models. Models will be developed of (i) the electrical fields generated by pulse trawls under different environmental conditions and (ii) the electrical fields inside marine organisms. Laboratory experiments will be conducted on the effect of electrical pulses on the behaviour and mortality of a selection of marine organisms. To cope with the diversity in species that will be exposed to pulse trawl fishing in the North Sea, species will be classified according to their building plan that determines their sensitivity to electrical stimulus. Fish samples of the various groups will be collected on board of pulse trawlers and analysed for injuries. Collected data will be compared to modelling results to optimize and fine-tune the boundary conditions and to estimate confidence intervals for model simulations.

WP2 will carry out field and laboratory experiments on the effect of electric pulses on the functioning of benthic ecosystems, and develop predictive models how ecosystem functioning is affected by pulse trawling. Field samples of the seabed will be taken from stations before and after pulse trawling. The species composition and functional characteristics will be determined, and the samples will be exposed to electrical stimulation or mechanical disturbance to measure the effect on geochemical fluxes.

WP3 will develop the tools to integrate the results of WP1 and WP2 in a spatially explicit predictive model of the distribution of fishing activities of pulse trawl fishers and its consequences for the catch, bycatch, and species that are not retained but come into contact with the electric field as well as the impact on the benthic ecosystem.

In WP4 the results obtained in WP1 – WP3 will be synthesized in an Impact Assessment that will quantify the consequences of a transition of the flatfish fleet from tickler chain beam trawls to pulse trawls. Consequences will be assessed for the bycatch and the impact on the benthic ecosystem (fish and benthic invertebrates). In order to be able to respond to the topics raised in the stakeholder interactions the integration will be organized in a flexible manner to investigate the effects of pulse trawling on the marine ecosystem. The project comprises of four work packages (Figure 11.10.5) dealing with the effects of electrical stimulation on marine organisms, both fish and invertebrate species; the effect on the functioning of the benthic ecosystem; the scaling up of the local effects to the effects at the scale of the fisheries and management area; final impact assessment of the transition of the fishery using mechanical stimulation (tickler chain beam trawls) to electrical stimulation (pulse trawls).

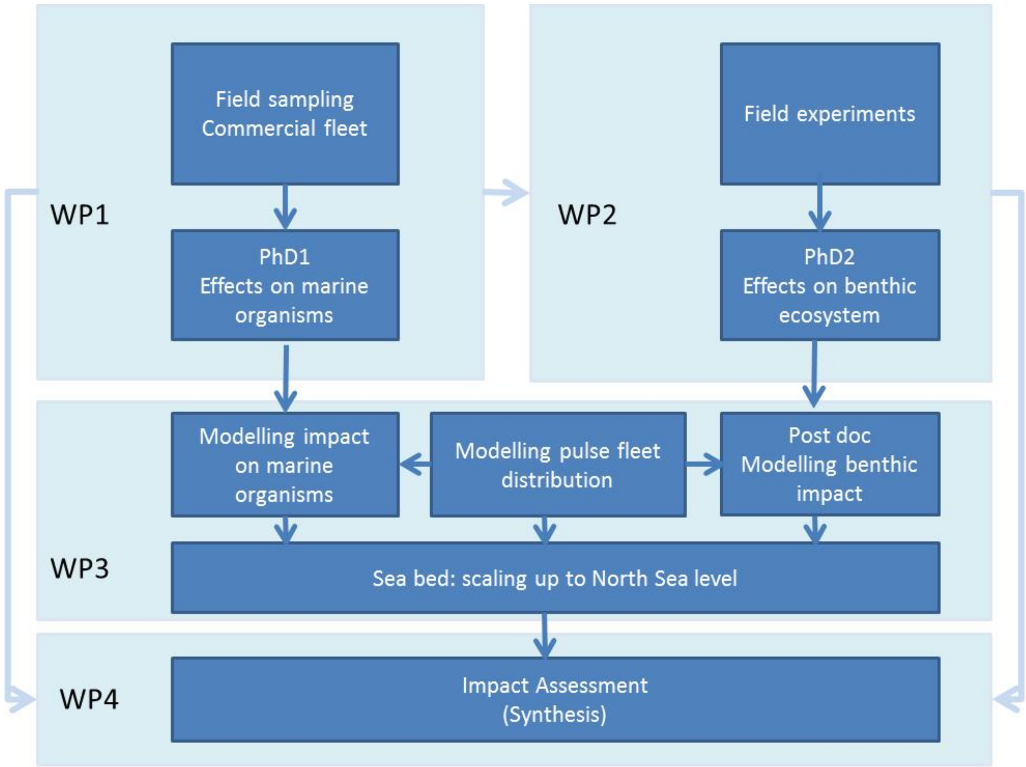

Figure 11.10.5. Relationship and flow of information between the work packages

11.10.8 Institute: Wageningen Marine Research

Contact: Dick de Haan (dick.dehaan@wur.nl)

Project: Field strength sediment measurements

Field strength was measured in and above the sediment around the conductors of a commercially practised pulse system. The set-up involved 3 pairs of conductors wired in parallel and spread out over an area of 5 x 5 m (Figure 11.10.6). This conductor arrangement was connected to a Delmeco pulse module system equivalent to the device applied in commercial pulse trawls. The measurements were executed in the sand layer of the Neeltje Jans rescue harbour at the sea side of the Oosterschelde barrier dam (NL). The sediment type was estimated as a hard layer of regular North Sea sand.

Field strength was measured in 5 steps of 45 mm alongside a conductor with the longitudinal axis at 55 mm distance from the electrode axis (Figure 11.10.7, left). In addition, field strength was also simultaneously sampled in the centre field along the centre axis of a conductor pair. For each position field strength was measured at 5 vertical levels in a range of 200 mm in and above the sediment, in steps of 100 mm. The conductors were positioned at a distance of 325 mm, measured over the centre axis. This distance matches to the measure used on the laboratory effects studies. The commercially practised distance is 0.425 m. The pulse amplitude tested was 60 $V_{0\text{-peak}}$ similar to the amplitude studied in the effect studies. The commercially practised amplitude of 50V $V_{0\text{-peak}}$ was measured in addition.

Measurement equipment

A number of 30 probes were designed and configured as 15 pairs with a total of 75 differential input channels. Probe signals were inputted to a CDAQ modular system (National Instruments). The chassis was AC powered and connected to a laptop by an

Ethernet connection link. Probe signals were inputted to a CDAQ modular system (National Instruments). The chassis was AC powered and connected to a laptop by an Ethernet connection link.

Figure 11.10.6. Overview of the full measurement arrangement with on rising tide.

Each CDAQ module supported a sample rate of 250 kHz maximum, which was down-graded by the number of input channels with a sample rate of 7.5 kHz for each measurement channel. Three additional differential channels were used to measure the current discharged to the three electrode systems involving three Rogowski inductive current probes (5 m V/A). The data acquisition was carried out using a virtual software tool based on Signal Express 2016 (Labview, National Instruments). The discharged current measured compared to the current monitored on the laboratory studies (de Haan *et al.*, 2016).

Figure 11.10.7. Left: Field strength probes positioned opposite a conductor. Right: Measurement system at high tide (2 m water height above the electrodes)

The preliminary results measured above the bottom compare to the data measure in the laboratory column (de Haan *et al.*, 2016), while the field strength ratings measured 10 cm in the sediment are significant compared to the values measured at similar distance above the bottom. The values listed refer to the position at 55 cm opposite the centre of a conductor and reflect the highest field strength. Field strength declined gradually towards the isolator junctions (Table 11.10.2).

Table 11.10.2 Overview of field strength results at a distance of 55 mm opposite the centre of a conductor.

Level (cm)	Field strength ($V.m^{-1}$) 60V 0-peak, I=32 A	Field strength ($V.m^{-1}$) 50V 0-peak, I=28A
+20	21	16
+10	68	55
0	>220	182
-10	45	37
-20	17	16

11.10.9 Institute: Wageningen Marine Research

Contacts: Benoit Berges (benoit.berges@wur.nl); Dirk Burggraaf (dirk.burggraaf@wur.nl)

Project: Ecosystem Acoustics

Monitoring of the pelagic ecosystem is a key component of the statutory survey programmes in the EU to deliver annual data underpinning policy drivers such as MSFD, CFP and DCF. The project aims to further develop acoustic ecosystem monitoring techniques (acoustic-optical). Therefore, it will keep the methods at the most current state and explore alternative ways to apply new and upcoming techniques.

With the shift in survey focus towards an ecosystem approach, data collected on acoustic surveys needs to be supplemented with standard and complementary sensors to improve monitoring and classification of (many more) species. There are higher demands on the interpretation of acoustic data and low-cost optical systems as proposed here (Figure 11.10.8) could be used to give valuable additional information about when, where, and how much is sampled by the trawl when verifying (groundtruthing) acoustic observations (Figures 11.10.9 and 11.10.10).

The acoustic-optical net camera sampling system, that was started off previously, will be further developed and be used during pelagic ecosystem surveys for improved ecosystem characterization. Additionally, trails with the net camera system Simrad FX80 on RV “Tridens” are planned.

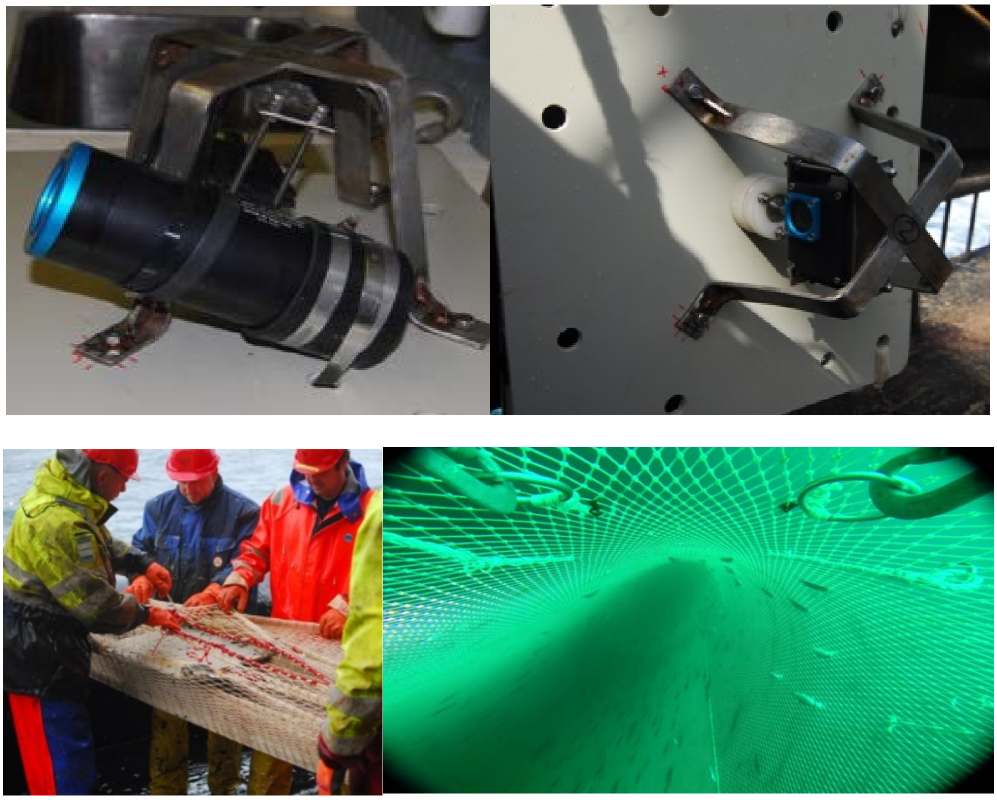

Figure 11.10.8. Impressions of the GoPro net camera system

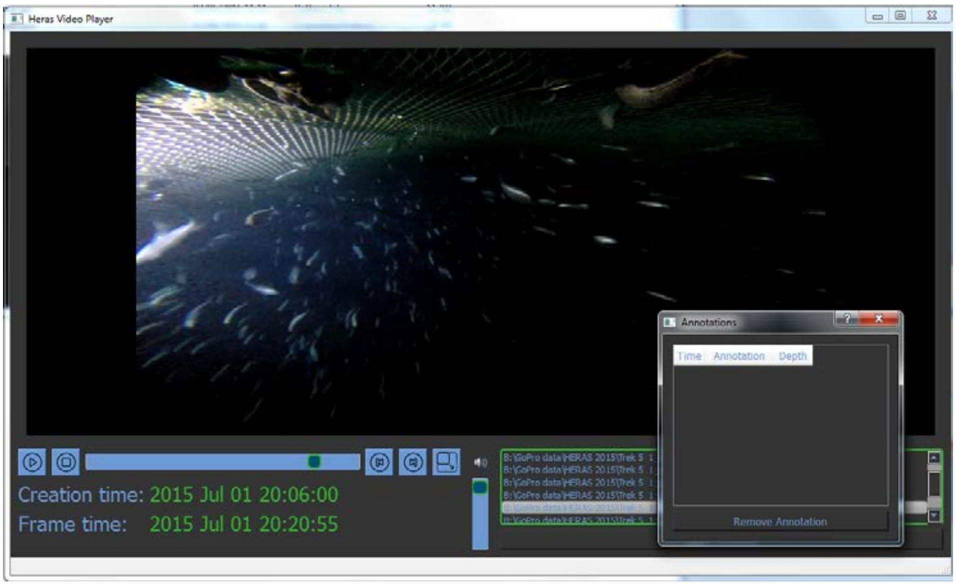

Figure 11.10.9. Software to process and annotate GoPro net camera footage.

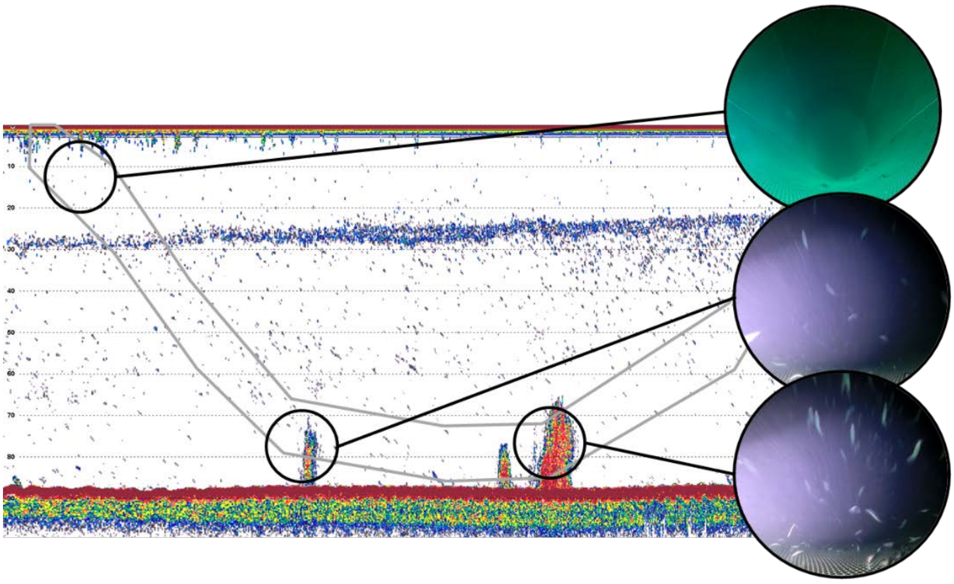

Figure 11.10.10. Net camera concept description to link acoustic observations with biological sampling.

11.10.10 Institute: Wageningen Marine Research, Wageningen Economic Research

Contacts: Marloes Kraan (Marloes.kraan@wur.nl)

Project: KB Towards a better understanding of Fishers' Behaviour

Under the Knowledge base fund of Wageningen Marine Research, we have been granted money for our project *Towards a better understanding of Fishers' Behaviour*. The project aims at developing a new transdisciplinary theoretical framework on fishers' behaviour and will develop new ways of collecting and analysing data of fishers' behaviour. The rational for the project is that successful fisheries management requires a thorough understanding of "fishers' behaviour", the collective set of decisions made every day on board of fishing vessels. Sudden and drastic changes in fisheries management, as e.g. in the case of the current implementation of the European landing obligation, poses the challenge whether our current knowledge of fishers' behaviour is sufficient to forecast changes in fisheries. There is general consensus that it is unclear how fishers will respond to new rules and regulations.

Fisheries behaviour research in fisheries science is predominantly done by natural scientists and economists. Mostly by assessing available catch and effort data and by modelling. Fisheries behaviour currently is thus approached by *inferring* human behaviour from statistics. From recent projects (CCTV, displacement, landing obligation) we have learned that our current research approaches can be strengthened by making use of social science methods (interviewing, focused group discussions). This 'add-on' approach can however be taken a step further by fully integrating the methods and by building a new theoretical framework of understanding fisheries behaviour. A more systematic collection of qualitative data on fishers' behaviour may improve our understanding and improve forecasts of the response of fishing fleets to changing policy. We will write a paper reviewing different approaches to understanding fishers' behaviour from the different sciences (biology, economy and social science) and we will revisit our data collection program and see whether changes can be made to collect more data.

11.11 Iceland

11.11.1 Marine and Freshwater Research Institute

Contact: Haraldur Arnar Einarsson (haraldur.arnar.einarsson@hafogvatn.is); Einar Hreinsson (einar.hreinsson@hafogvatn.is); Hjalti Karlsson (hjalti.karlsson@hafogvatn.is).

Selectivity in four-panel T90 codends.

In recent years, the selectivity research on bottom trawls has been focused on evaluating the effect of size and design of the trawl body itself on codend selection. It was demonstrated that both trawl design and trawl size had a significant effect on the codend selection. As an attempt to reduce this effect (variance) and to improve fish quality, a four-panel codends was set to focus. First trials were done in 2014 with traditional four-panel codend that showed increased L_{50} in same mesh size. It was the opinion of fishers that the quality of the fish also improved. The fishing gear producer Hampiðjan designed a four-panel codend of 155 mm inside mesh size in the T90 formation. This codend design is mounted on (hung on) lengthwise frame lines. Trials with this new four-panel design were made on a commercial trawler in October 2015. Many commercial vessels are now using the T90 four-panel codend, and further work is ongoing. In cooperation with the Fisheries and Marine Institute of Memorial University of Newfoundland, flume tank tests on T90 four-panel codends are in progress. More selection data sampling for different mesh sizes and species are planned. In spring 2017, a test will be conducted on a commercial trawler in order to measure selectivity of redfish in ~110 mm T90 meshes and then in autumn the same type of codend will be measured in the shrimp fishery with ~37 mm mesh. (HAE).

The Inshore shrimp fishery: Testing a modified trawl design (topless) with illuminated footrope against a conventional sorting grid.

The inshore shrimp stocks (*Pandalus borealis*) are slowly recovering after almost collapsing ten years ago, and traditional selection issues such as bycatch of juvenile cod, haddock, and herring have emerged again. The use of sorting grid (Nordmore) has been implemented by the authorities but heavily opposed by the fishers. The defiance is based on two main arguments. First, the use of the grid on inshore grounds can cause huge catch losses due to seaweed grid clogging. Second, the grid will not cope with the relatively high catch rates (up to 100–200 kg/min) common in the inner fjord areas. In addition, it is known to both fishers and scientists that excluding juvenile cod, haddock, and herring from shrimp of similar body size are not as effective as when dealing with these species 1 year or older. Therefore, the MFRI and the vessel owners joined forces in 2014 and initiated a research project with the goal of comparing the sorting grid against a modified trawl design (topless) with illuminated footrope. So far comparing tests have been made in three separate research trips, one in March 2014 and two in 2015, March and November. In these experiments three vessels were used, one rigged with conventional trawl and covered codend. The second vessel was rigged with conventional trawl and a 19 mm sorting grid, and the third vessel was rigged with modified trawl design (topless) and illuminated footrope. The results are still being processed, but already indicating that the modified trawl with footrope illumination could be an alternative to the sorting grid. (HK and HAE).

***Nephrops* Fishery, selection and bottom impact.**

Bycatch of juvenile fish in the Icelandic *Nephrops* fishery is of constant concern. In April 2015, trials with divided codends similar to what has performed successfully in

Denmark where made on a commercial trawler. The upper codend had a mesh size of 135 mm with a T90 formation. The lower codend had 90 mm inside mesh and was rigged with a steel frame at the front end. Due to some practical disadvantages of this setup, i.e. twisted codends during hauling and deck handling issues, further trials are planned this year. There have been concerns about the trawl doors and twin-rig clumps having negative impacts on the Nephrops habitat, which is a soft muddy bottom. Footage from video surveys on *Nephrops* fishing grounds will be analysed and trials with semi-pelagic doors are planned. (HAE).

11.12 Scotland

11.12.1 Marine Scotland – Science Marine Laboratory Aberdeen Scotland

Trials to compare Deep Vision footage from a demersal trawl with actual catch.

Experimental sea trials were carried out on RV Alba na Mara during November 2016 in the Moray Firth, Scotland on the use of Deep Vision in a demersal trawl. Deep Vision is a stereo camera system developed at IMR Bergen which films fish passing down the taper of a trawl allowing species identification and measurement to be made. It is envisioned that with development Deep Vision could be integrated into a further system which could facilitate removal of unwanted fish from the trawl during actual towing operations. Previous footage from Deep Vision has only been obtained from a pelagic net. Here the attempt was made to obtain footage from the system installed in a demersal net, over a range of sediment types, and hence turbidity, and compare visual data to actual codend catch in each sediment type.

Good footage of various species of fish undergoing capture was obtained on a range of sediments (gravel, sand, mud). Comparisons between length frequencies as retained by the codend and estimated from Deep Vision footage will be undertaken in Norway during 2017.

Further details can be got from j.drewery@marlab.ac.uk

Catch Comparison experiments using a large (600mm) Square Mesh Panel (SMP)

A short set of catch comparison trials were carried out on RV Alba na Mara during November 2016 in the Moray Firth using a single trawl. The trawl was fished on Nephrops/whitefish grounds with the SMP alternatively covered/uncovered with 80mm diamond mesh to provide a comparison in catch rates. The data will be analysed in 2017.

Further details can be got from j.drewery@marlab.ac.uk

Trials to investigate the physical impact of towed gear components on the seabed.

Experimental sea trials were carried out on the RV Alba na Mara using a towed sledge during May 2016 in the inner Moray Firth, Scotland to estimate hydrodynamic drag for netting samples towed close on the seabed and to quantify the sediment remobilized by the turbulence caused by netting.

There were three frames made from two triangular sheets of 25 mm thick HDPE measuring 400 mm high by 850, 650, and 450 mm long, and held apart by three galvanised steel M20 threaded rods so that the internal width was 1326 mm. There were five netting samples for each frame measuring 120, 100, 80, 60, and 40 meshes wide giving five different solidity measurements. The netting was 50 mm diamond mesh (between knots) of 3 mm diameter double polyamide (nylon) twine.

In total 57 sledge tows were conducted. Drag and particle size distributions from the plume behind the netting frames were measured and these data will be analysed to relate the quantity of sediment mobilized to the netting drag.

Further details can be got from b.oneill@marlab.ac.uk or k.summerbell@marlab.ac.uk

Investigating the use of light to promote the selectivity of towed gears.

Trials took place in March 2016 with a fibre optic cable attached to a rigid grid in the extension section of a trawl gear. The cable was a 5 mm diameter multi-strand side emitting fibre optic cable that was illuminated by a PhotoSynergy Ltd SLS5000 unit which houses a single green LED and was powered by a 12 V DC supply. The grid was made from HDPE and was 1.2 m high, 0.75 m wide and had 145 mm bar spacing. It was inclined at approximately 60° to the horizontal and fish which passed through the top half of the grid they were directed to the upper codend and those that went through the lower half were directed to the lower codend.

There were 22 during daylight hours (classified as being hauled before sunset) and 21 at night (ie the net was shot after sunset). And in each case there were 5 or 6 hauls where (i) the top half of the grid was illuminated, (ii) the bottom half of the grid illuminated, (iii) the whole of the grid illuminated and (iv) none of the grid was illuminated. The data are being analysed at present.

Further details can be got from b.oneill@marlab.ac.uk, or k.summerbell@marlab.ac.uk

The Gear Innovation Technology and Advisory Group II (GITAG II)

GITAG II has been set up to encourage skippers and fishers from all sectors to put forward innovative ideas for more selective gears which will help their targeted fishery become more sustainable.

The Group was formed during 2016 after the Scottish Fishers's Federation secured EMFF funding from Marine Scotland to develop and trial innovative fishing gear exploring practical solutions aimed at reducing the amount of discards.

Further information is available from Jennifer Mouat (theaegirconsultancy@btinternet.com)

Trials to assess the effect of bobbin groundgear and a 200mm square mesh panel to reduce unwanted bycatches in the commercial *Nephrops* fishery.

Trials were held to assess whether the unwanted bycatch of round and flatfish could be reduced in the *Nephrops* trawl fishery using a modified *Nephrops* trawl incorporating 200 mm bobbins and a 200 mm square mesh panel.

Catches of *Nephrops* and monkfish remained consistent with that of a standard commercial *Nephrops* trawl. There were significant reductions in relative catch rates of cod and larger haddock (>25 cm) and whiting (>28 cm) and no difference between the two trawls for haddock below 24 cm and for whiting below 27 cm.

There was a significant reduction in the quantities of smaller common dab (<19 cm) and long rough dab (<21 cm) that were caught when using the modified trawl. However, significantly larger plaice above 30 cm were retained by the modified trawl.

Further information is available from Matt Kinghorn (Matt.Kinghorn@gov.scot).

11.13 Norway

11.13.1 Institute of Marine Research

Trawl modification for improving size selection in the shrimp fisheries.

IMR runs a project on the effect of modifying trawl design on size selection of shrimp. In some previous studies, observations have been made that catches of small shrimp, as well as bycatches of small fish, have changed with alterations in trawl design. The project is run in collaboration with fishers and fishing gear designers. The experiments conducted in 2016 show that by reducing shrimp trawl length, by steepening the cutting rates of the trawl bellies, catches of small shrimp can be significantly reduced. The vessels that have reduced the length of the trawls, have experienced greater distance between trawl doors, indicating less drag of the sorter trawls. These experiments will continue in 2017.

Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no)

Catch release system for demersal trawls

In recent years, it has become a great challenge for the demersal trawler fleet to limit their catch sizes. The past several years, IMR has been working on solutions for limiting catches by releasing excessive fish from the codend. In previous years, underwater observations were made in the cod fisheries in the Barents Sea. Early 2016, further tests and observations using both remotely operated cameras and fixed camera systems. Modifications of the system were made as well as experimenting with alternative solutions. About half of the Norwegian trawler fleet has temporary dispensation to use the system and reports to the Directorate of Fisheries. In some instances, however, fish that have not entered the codend, mainly fish in vicinity of the grid, are 'washed' out at the surface. In 2017, experiments will be conducted to further observe the catch release system and attempt to reduce the risk of fish floating out the escape holes at surface.

Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no)

The effect of codend circumference on size selection of Northern shrimp

In northern Norway, a minimum catch length for shrimp is set of 15 mm carapace length in the trawl fisheries. While the codend mesh size is regulated, codend selectivity studies have not been conducted since in the 1980's, and not in Norwegian waters since in the 1970's, before the Nordmøre grid was made mandatory. Therefore, IMR conducted a selectivity experiment, using the twin trawl method onboard a coastal shrimp trawler in the fjord fishery in northern Norway. The results show that the size selectivity for northern shrimp is not in line with the minimum catch size and that codend circumference greatly affects the size selectivity.

Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no)

Bycatch reduction in the trawl fishery for Greater argentine

In collaboration with SINTEF, IMR conducted an experiment to reduce bycatch in the fishery for Greater argentine (*Argentina silus*), mainly focusing on reducing catches of haddock. A square mesh escape panel was inserted in front of the codend, in an attempt to reduce haddock catches. During the hauls, the escape panels were filmed, using Gopro cameras and red (620 nm) light, to avoid affecting fish behaviour. This modification of the trawl reduced in great reduction of haddock catches, but Greater argentine also escaped through the panel, resulting in catch loss.

Contact: Ólafur Arnar Ingólfsson (olafur@imr.no) / Manu Sistiaga (manu.sistiaga@sintef.no)

Sampling trawl with ruffled small mesh liner nets

Trials have been carried out in 2016 with "ruffled" 8 mm mesh liner panels mounted in the aft part of a sampling trawl to reduce the clogging and escapement of small individuals (young of the year fish and zooplankton). The 8 liner nets, each 6 m long, are installed as a series of overlapping cylinders inside the trawl, and are attached only at the leading edge so that they wave gently with the water current. In addition, to obtain the same trawl geometry independent of warp length, the front part of the trawl, i.e. the fishing circle, was made of square meshes. By combining this with large pelagic trawl doors and short bridles, the idea was to obtain maximum opening of the square meshes with short warps, i.e. with the trawl at surface. With maximum opening of the square meshes along the fishing circle, this should prevent the trawl to be further spread when longer warps are deployed. The ruffled panels prevented small individuals from escaping and clogging was not observed. The high drag of the trawl prevented the trawl to be fully spread with short warps. Larger trawl doors need to be used. Further tests will be carried out in 2017.

Contact: Arill Engås (arill.engaas@imr.no)

Deep Vision

The Deep Vision system, developed by Scantrol Deep Vision and the Institute of Marine Research, continues to be refined. Work in 2016 focused on testing the system in bottom trawls, implementing image processing routines to automatically select objects from images, and testing a system to mount the camera system inside a trawl without a large, rigid, frame.

Contact: Shale Rosen shale.rosen@imr.no

Using artificial light in fish pots

This project aims at finding a method to attract krill to cod pots – where the krill will act as a motivating bate for cod to enter the pot. Underwater camera observations have shown that krill are attracted by light and that cod feed on krill. The first field tests using artificial light in pots targeting cod, were carried out in 2015. These initiating trails gave no significant effect of adding a light to the baited pot. Last spring, we performed controlled laboratory studies to unveil, the effect of wavelength composition, light intensity and flickering frequency on krill and cod's repulsion and attraction response to a light stimulus. The most attractive individual wavelength was green (530 nm), while broadband (425–750 nm) white light was an equally attractive light source. The most promising light stimuli for krill were tested to determine whether they would have repulsive or attractive effect on cod. These light stimuli appeared to be slightly repulsive for cod. A fishing trial was carried out last fall comparing pots with white broadband and green artificial light and squid bait with pots baited with squid bait only. White light was tested at two different intensities (low and high) while green was only tested at low intensity. High intensity white light gave the best result with catches up to 200 kg of cod in one pot. More comprehensive trials regarding krill attraction to different light stimulus will be carried out this summer and fall, using a comparative study with light traps in the field. Following, the best light to attract krill in the field study, will be tested out in pot fishing trails this fall.

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Light-buoy development for purse-seine

There is a widespread light -fishery for pelagic species like sprat, saithe, herring, mackerel and horse mackerel using purse in Norwegian waters. The lightvessels used in this fishery are normally small old fishing vessels or alike, equipped with gas lights using diesel generator as energy source. A number of challenges with regards to operation, energy use, pollution and cost, are apparent when using lightvessels. A battery driven light buoy using LED lights is proposed to replace the lightvessels. A report is produced as background information for the development of a light buoy. Description of existing gas-lights used in this fishery is given along with a comparison with two potential replacements LEDs. The lights spectral composition was compared with spectral sensitivity of two related pelagic species and showed low overlap. Recommendation on how to proceed with the development of a light buoy is given.

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Best practices for releasing fish from purse-seines

It is sometimes necessary to release fish captured in purse-seines, either because they are of the wrong size or catches exceed the vessel's capacity. A set of "best practices" being developed by researchers, fisheries managers and purse-seine fishers to release Atlantic mackerel (*Scomber scombrus*) and Atlantic herring (*Clupea harengus*) while minimizing physical damage and stress. It is important that release be conducted in a calm and controlled manner over a sunken portion of the bunt-end of the seine rather than cascading over the top/floatline. More information on the "best practices" is available at: http://www.imr.no/filarkiv/2016/10/hi_nytt_2_2016_web_norsk.pdf/en.

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Ghost fishing by pots

In a coordinated effort by the National Diver's Association and the IMR more than 2000 lost pots have been retrieved by local diving clubs. Catch and gear data (including a photo of the pot) is reported for each pot. The data will be used to estimate bycatch rates and to elucidate the major causes of pot loss. Experiments to estimate the degradation rate of the cotton twine was carried out in 2016. The thinner twines (< 2.5 mm diameter) were completely degraded in 6 months. The twines were kept in fine-meshed bags and the results indicated that this may underestimate the degradation rate. A new series of degradation test was initiated in Dec 2016 using free hanging twine. Preliminary results indicate that degradation progresses up to 50% faster compared to the first experiment. A study of the catch dynamics of simulated lost king crab pots was initiated in Dec 2016. The pots are lifted monthly to examine the escape of trapped crabs and the entry of new crabs into the pots as a function of time post simulated loss. Upon redeployment all crabs are tagged with PIT tags.

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Selectivity of wrasses

The last years about 20 million wrasses (mainly corkwing wrasse (*Symphodus melops*) and goldsinny (*Ctenolabrus rupestris*)) have been caught live for use by the fish-farming industry in de-lousing of salmon. The fish are caught on pots and fykenets.

Experiments made in cooperation with commercial fishers indicated that it is possible to fish selectively with pots for ballan wrasse (*Labrus bergylta*) using escape grids with 25 mm wide rectangular vents. For corkwing and goldsinny selectivity experiments was estimated for grids with 11 and 12 mm rectangular escape vents. 12 mm wide vents were found to be the best compromise between loss of legal goldsinny and capture of undersized corkwing. Probability of contact with the grid was significantly lower for goldsinny than for corkwing.

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Alternative longline baits

The most common bait types (mackerel, herring, squid, saury) used by the Norwegian longline fleet are also used for human consumption. Bait prices have increased over the last years due to increased demand for marine food resources, and bait costs comprise a significant proportion of the total costs for the longline vessels. An initiative has therefore been taken by the industry to develop an alternative longline bait that is not based on resources used for human consumption. This collaborative project involves three commercial companies and two research institutes (Institute of Marine Research and Nofima Marin). Two of the companies have developed baits with different scent and flavour that have been tested in behavioural studies and fishing trials for cod. Some of the bait types tested showed promising results.

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Development of acoustic methods for catch and gear monitoring in purse-seines

In 2016 we have continued the development of improved acoustic methods for catch and gear monitoring in purse-seine fisheries. The work focuses on the use of multibeam sonars and 3D positioning transponders that can be attached to the seine. One of the aims is to provide fishers with better tools for early catch and gear monitoring and identification, such as school biomass estimation, school behaviour in relation to the seine and seine visualization. This is important to ensure efficient capture and identification of too large catches that can be safely released when necessary. A better understanding of school behaviour inside the seine is also important for establishing fishing regulations and methods that ensure high survival of unwanted catches that are released from the seine. This work is carried out in cooperation with Kongsberg Maritime and as part of CRISP, a centre for research-based innovation (http://crisp.imr.no) and the project "Reducing slipping mortality in purse-seines by understanding interactions and behaviour"

(https://www.forskningsradet.no/prosjektbanken/#!/project/243885/no).

Tenningen, M., Macaulay, G. J., Rieucau, G., Peña, H., and Korneliussen, R. J. 2017. Behaviours of Atlantic herring and mackerel in a purse-seine net, observed using multibeam sonar. – ICES Journal of Marine Science, 74: 359–368.

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11.13.2 SINTEF Ocean

Managing trawl catches by improving the hydrodynamic performance of sorting grid sections (Catch control II)

The main objective of this project is to develop sorting grid section(s) (combined with a codend) for the Barents Sea demersal trawl fishery that provides high selective performance and good control over catch sizes even when exposed to extremely high catch rates. The latest experiment in this project was carried out in March 2017 with a 4-panel inverted Sort-V section without lifting panel, in which the sorting grid simultaneously work as guiding panel directing fish towards a squared mesh panel located in the top panel of the section. Preliminary results good water flow through the new grid section, high contact of fish with the grid and generally good size selection through the grid. In addition, there was additional size and species selection through the meshes of the square mesh panel fixed at the top panel of the section. Data were collected for haddock, redfish and cod.

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Improving release efficiency of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) in the Barents Sea demersal trawl fishery by stimulating escape behaviour

We tested the ability of stimulators to improve the release efficiency of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) through the meshes of a square mesh section installed between the extension piece and the codend of a trawl. The square mesh section was tested in three different configurations during experimental fishing: without any stimulation device, with a mechanical stimulation device, and with LED light stimulation devices. We analysed and compared the behaviour of cod and haddock in all three configurations based on release results and underwater recordings. Parallel with the fishing trials, we carried out fall-through tests to determine the upper physical size limits for cod and haddock to be able to escape through the meshes in the square mesh section. This allowed us to infer whether lack of release efficiency was due to fish behaviour or release potential of the square meshes in the section. The results showed that the escape behaviour of haddock can be triggered by mechanical stimulation. In contrast, cod did not react significantly to the presence of mechanical stimulators. LED light stimulation had some effect on the behaviour of haddock, but not on cod, although the results were inconclusive and had no significant effect on the release efficiency. The release efficiencies of cod and haddock estimated for the square mesh section in any of the three configurations tested were not as good as those estimated for mandatory sorting grids. However, the mechanical stimulation device tested in this experiment showed potential for improve the release efficiency of haddock.

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Development of biodegradable gillnets to reduce the effect of ghost fishing in Norwegian deep-sea gillnet fisheries (BIOgillnet)

Three sets of comparative fishing experiments have been carried between biodegradable and nylon gillnets. The first experiment was carried out in May-June 2016 on Greenland halibut. Two sets of 200 mm mesh size gillnets (each set composed of eight nylon and eight biodegradable gillnets) were used in the experiment. The results showed that the nylon gillnets caught 6% more fish than the biodegradable gillnets. The second experiment was carried out in October-December 2016 on saithe and cod. Two sets of 135 mm mesh size gillnets (each set composed of eight nylon and eight biodegradable gillnets) were used in the experiment. The results showed that the nylon gillnets caught approx. 25% less cod than the nylon gillnets. The difference in colour of the gillnets may have influenced the results (the biodegradable gillnet was green and the nylon gillnets were blue). Underwater video recording showed that the blue nylon gillnets were less visible than the green biodegradable gillnets.

These observations were made with natural light, white and red artificial light at surface and to 100-meter depth. The third set of experiments were carried out in January-March 2017 on migrating cod. Two sets of 200mm mesh size gillnets (each set composed of eight blue nylon gillnets and eight green biodegradable gillnets) were used in the experiment. The results showed 15% difference in catch in favour of the nylon gillnets. A degradation experiments started in June 2016. Samples of biodegradable materials and nylon were set in pots and submerged at sea at 30, 50, and 70 m depth. The goal is retrieve one set of samples for the pots every 90 days and then carry out tensile strength measurements to assess for loss of strength. This experiment will last until December 2017. An accelerated degradation experiments were started in December 2016. We have cultivated bacteria extracted from the gillnets used in the first fishing experiments in May–June 2016. Different bacteria concentrations are used to speed up the degradation process. The results from this experiment are still not available.

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Industrial exploitation of mesopelagic fish (ILLUM)

An industrial project was started in May 2016 to identify the potential and the challenges for industrial exploitation of mesopelagic fish species in the Northeast Atlantic. A 30-cruise was carried on board a commercial vessel to assess the area NEAFC RA 1 (XXR Reykjanes Ridge). Three different activities were the main focus of the cruise: 1) Mapping the geographical and vertical distribution of mesopelagic fish in the area NEAFC RA 1 (XXR Reykjanes Ridge) 2) Perform experimental fishing with focus on species identification, vertical distribution, size distribution, bycatch, catch rate and underwater video recording. 3) Preliminary production experiments with the aimed at preprocess and ensilage the catch with a mobile pilot plant on board the vessel; also chemical characterization of the raw material for mapping dry matter and ash content, content of protein and fat as well as fatty acid and amino acid composition.

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Improving the design, efficiency and environmental friendliness of snow crab pots

This newly started project aims to increase the catch efficiency and environmental friendliness of the new commercial Norwegian fishery for snow crab in the Barents Sea. The existing current technology for harvesting snow crab in the Barents Sea is an adaptation based on the neighbouring Canadian fishery, and the supplier industry is eager to offer a technology that better fit the Norwegian conditions. The snow crab fleet are experiencing area conflicts, low efficiency in parts of the year and ghost fishing challenges. With an increase of efficiency in the fishing gear for this new species, the development of a mechanism for anti-ghost fishing, and use of biodegradable materials in the construction of the pots, these challenges can be reduced to something negligible.

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Deep-water tornado trolling for whitefish

In this project a system for deep-water tornado trolling is being developed. This can be explained as a jig-/trolling line going continuously around in a closed loop from the vessel and through a stabilized, wide pulley hanging at a desired depth in a line from the vessel. The trolling line is automatically driven and shall be able to operate at depths down to 200 m and more to catch cod, haddock, and saithe.

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Technology development for effective harvest of snow crab (Chionoecetes opilio)

Snow crab fishery tends to become a new billion industry in the Barents Sea. Scientists predict that this new species will yield values for the Norwegian fishing fleet for about 3.5 Billion NOK within 2020. This is a species, which is living far out in the sea and is available only for the large seagoing fishing fleet. The offshore fishing fleet in Norway is highly advanced vessels, with educated crew and high demands for working conditions. The countries currently fishing for this species offshore (Russia and USA) relies on cheap labour and low-cost technology.

The main objective is to develop a profitable and sustainable technology platform for harvesting snow crab based on Norwegian demands for EHS, salaries and product quality. Secondary objectives are to reduce labour force on deck and in the factory and to eliminate all processes on board which cause unacceptable risk for crew members, both risk for direct injuries and injuries caused by long-term stress. The project will also identify the environmental acceptance for the snow crab when it comes to handling, live storage and transportation. The last objective is to define and develop best practice for sustainable fishery of snow crab.

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Danish seine: Computer based design and operation

The main objective of this project was to develop software tools for demersal seine fishing that ease future transition to the environmentally friendly Danish seine fishing method and that will support development of more optimized gear designs. The project has been finalized in 2016 and five scientific papers addressing different aspects of demersal seining have been submitted to or are already published in journals with peer review:

Herrmann, B., Larsen, R.B., Sistiaga, M., Madsen. N.A.H., Aarsæther, K.G., Grimaldo, E., Ingolfsson, O.A., 2016. Predicting Size Selection of Cod (Gadus morhua) in Square Mesh Codends for Demersal Seining: a Simulation-based Approach. Fisheries Research 184: 36-46.

Madsen, N.A.H., Aarsæther, K.G., Herrmann, B., Hansen, K., Jensen, J.H., 2016. The Physical Behaviour of Seine Ropes for Evaluating Demersal Seine Fishing. Journal of Offshore Mechanics and Arctic Engineering 138, pages 10. DOI: 10.1115/1.4033778.

Herrmann, B., Krag, L.A., Feekings, J., Noack, T., 2016. Understanding and predicting size selection in diamond mesh codends for Danish seining: a study based on sea trials and computer simulations. Marine and Coastal Fisheries 8: 277-291.

Notti, E., Brčić, J., De Carlo, F., Herrmann, B., Lucchetti, A., Virgili, M., Sala, A., 2016. Assessment of the relative catch performance of a surrounding net without the purse line as an alternative to a traditional boat seine in small scale fisheries. Marine and Coastal Fisheries, Volume 8, pages 81-91.

Madsen, N.A.H., Aarsæther, K.G., Herrmann, B., 2016. Predicting the effect of seine rope layout pattern and haul-in procedure on the effectiveness of demersal seine fishing: A computer simulation-based approach. Under review at PlosOne.

Further a symposium paper (Madsen, N.A.H., Aarsæther, K.G., Herrmann, B., Hansen, K., Jensen, J.H., 2015. The physical behaviour of seine ropes for evaluating demersal seine fishing. Proceedings of the International Conference on Offshore Mechanics and Arctic Engineering – OMAE 7, OMAE201541892) received the "OMEA 2015 Best Paper Award".

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Effect of trawl and codend construction on the filet quality of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*)

The objective in this project is to evaluate the potential for improvement on fish quality obtained by modifying the trawl constructions used in the Barents Sea today. The investigation aims at clarifying if changing from two-panel constructions to four-panel constructions and using knotless materials can reduce the presence of bruises in fish filet. The quality of the fish delivered by a vessel depends on the initial quality of the fish taken onboard. Many trawlers in the Barents have reported problems and substantial economical loses due to lower quality on the fish delivered. Thus, getting rid of blood marks or bruises created by the gear during the fishing and hauling operations is of special interest for the fleet.

In the project we aim at answering the following questions:

- Is the quality of fish caught with trawls constructed in four panels better that that of the fish caught with trawls constructed in two panels?
- Does the use of knotless codends reduce the amount of bruises or blood marks in fish filet? Should this type of netting also be used in the extension piece and grid section?
- Does the use of newly designed gentle codends give quality wise any advantage compared to traditional codend designs?

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How many fish need to be measured in trawl selectivity studies?

The aim of this study is to provide practitioners working with trawl selectivity with general and easily understandable guidelines regarding the fish sampling effort necessary during sea trials. Particularly, we wanted to provide guidelines on the number of fish necessary to catch and length measure in a trawl haul in order to assess the selectivity parameters within an intended maximum uncertainty level. In addition, the study investigated the dependence of this uncertainty level on the experimental method applied for the data collection and on the potential effects of factors like the size structure in the catch relative to the size selection of the gear. We based the study on simulated data created from two different fisheries: the Barents Sea cod trawl fishery and the Mediterranean Sea multispecies trawl fishery represented by the red mullet. The purpose of using these two completely different fisheries was to obtain results that can be used as general guidelines also for other fisheries. The results showed that the uncertainty in the selection parameters decreased with increasing number of fish measured and that this relationship could be described by a power model. The sampling effort needed to achieve a specific uncertainty level for the selection parameters L50 and SR was always lowest for the covered codend when compared to the paired-gear method. In many cases, we observed that to keep a specific uncertainty level the amount of fish needed to measure with the paired-gear method is around 10 times higher than with the covered codend method. The trends observed for the effect of sampling effort in the two fishery cases investigated were similar. A scientific paper was published:

Herrmann, B., Sistiaga, M., Santos, J., Sala, A., 2016. How many fish need to be measured to effectively evaluate trawl selectivity? PlosOne. http://dx.doi.org/10.1371/journal.pone.0161512.

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Estimation of the effect of gear design changes in catch efficiency: methodology and a case study for a Spanish longline fishery targeting hake (*Merluccius merluccius*)

We outline a method to estimate the relative catch efficiency of different fishing gear designs based on comparing catch data. The method described does not require equal number of deployments or alternation between the gears to be compared, and accounts for multiple competing models describing the data by using multi-model inference. Further by applying a double bootstrapping procedure the method accounts both for the uncertainty in the estimation resulting from between deployment variation in catch efficiency and availability of fish, and the uncertainty on the size structure of the catch for the individual deployments. Finally, incorporating the multi-model inference into each conducted bootstrap the method also accounts for the uncertainty due to uncertainty in model selection. Using the outlined method, we investigated the effect of gear design changes in catch efficiency for a Spanish longline fishery targeting hake (*Merluccius merluccius*). We tested and compared four different designs against the traditional design applied in the fishery; a new automatized design that differed in hook size, snood line length and snood line diameter, and three designs where only one of the parameters was changed at the time. The new design is favourable for the Spanish demersal hake fishery because the deploying and hauling processes are automatized, meaning that the manpower needed to conduct the fishery would be decreased. However, this study demonstrates that adopting the new automatized design results in a significant decrease in catch efficiency. The analysis conducted revealed that the reduction in catch efficiency was consequence of the thicker snood line applied in the new design. The change in hook type and snood line length used had no effect in the efficiency of the fishery. A scientific paper was published:

Herrmann, B., Sistiaga, M., Rindahl, L., Tatone, I., 2017. Estimation of the effect of gear design changes in catch efficiency: methodology and a case study for a Spanish longline fishery targeting hake (*Merluccius merluccius*). Fisheries Research 185: 153-160.

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Effect of bait change and bait size on the catch efficiency in the European hake (*Merluccius merluccius*) longline fishery

In this project we investigated the effect of bait change and bait size on the catch efficiency for a Spanish demersal longline fishery targeting hake (*Merluccius merluccius*). We tested and compared three different species of fish and squid against the traditional bait used in the fishery: whole sardine. In addition, we tested whether changing the size and shape of a certain species of bait affects the catch efficiency for different sizes of hake. The different baits tested are all compatible with an automatic longline system that is considered as an alternative to the traditional gear used, where whole sardine hooked by the eye is used as bait. The results demonstrated that all four alternative bait species tested result in a significant decrease in catch efficiency for the fishery. We tested herring, squid, mackerel and sauri. The use of chopped sardine and chopped herring compared to the use of whole fish also resulted in a reduction in the catch efficiency of the gear. In addition, we found that reducing bait size tended to reduce the catch efficiency of bigger hake while increasing the catch efficiency for smaller hake. This confirms that bait size can have a size selective effect in longline fishery.

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Escape risk for goldsinny wrasse (*Ctenolabrus rupestris*) and lumpfish (*Cyclopterus lumpus*) from aquaculture cages: development of RENSELECT

The high densities of sea lice present in the Norwegian salmon aquaculture cages represent one of the main problems of the industry today. One of the preferred treatments used to reduce the densities of this parasite in the cages is the use of cleaner fish. In Norway there are different species of cleaner, 4–5 different wrasse species (belong to the Labridae family) and lumpfish. These fish species feed on the sea lice and help maintaining its densities at lower levels, which are not damaging for the salmon. The main advantage of using cleaner fish contra using other more traditional methods like industrial chemicals is that in principle, the method is more environmentally friendly, less risky to apply and more gentle for the salmon. However, the use of cleaner fish is not completely without environmental issues. Over the last years, the Norwegian salmon industry has used ca. 20 million cleaner fish per year, and the demand for the fish has been high throughout the country. Consequence of this demand, high volumes of cleaner fish are moved over long distances (sometimes several hundreds of kilometres) from its original habitat into areas where these species naturally do not exist or can belong to another genetic variety.

The relation between the meshes used in the salmon cages and the salmon and cleaner fish sizes in the cages has not been properly studied in Norway. Only a few basic guidelines that give an indication of the minimum sizes of fish that can be put in the cages can be found. In this project we apply the FISHSELECT methodology to goldsinny wrasse (*Ctenolabrus rupestris*) and lumpfish (*Cyclopterus lumpus*), which are respectively the smallest cleaner fish species and the newest cleaner fish species used by the industry. The aim is to provide the aquaculture industry with proper guidelines for the sizes of these two cleaner fish species they can use. The method has already been applied to salmon smolt.

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11.13.3 The Arctic University of Norway UIT, Faculty of Biosciences, Fisheries and Economics – Norwegian College of Fishery Science

Bycatch reduction in the Northeast Atlantic shrimp fisheries

The Norwegian fisheries authorities have in the last years had focus on the bycatch issues related to shrimp fisheries. Thus, there is a national initiative where the university of Tromsø, SINTEF, the Institute of Marine Research and Møreforskning have been joined together in a large project to investigate alternatives that can reduce the bycatch levels at the fisheries.

In the last year, the University of Tromsø and SINTEF have carried out experiments where initially, the selectivity of the gear currently used by the fleet was investigated. The fleet fishing shrimps must use a 19 mm bar spacing sorting grid followed by a 35 mm diamond mesh size selective codend. The selective properties of these whole selective gear (grid + codend) had never been evaluated before and showed to produce special selectivity curves that needed the development of a new model, which is now developed. In addition to this initial basic study, new alternative gear modifications have been tested. One of the studies carried out focused on the use of a short guiding funnel in front of the grid and LED-lights in the fish outlet of the grid. The study showed that different fish species react differently to the presence of the LED lights and that the use of a short or long funnel is a matter of balance between the improved fish bycatch selectivity obtained and the affordable shrimp loss. Other modifications studied include the use of a longer version of the sorting grid, which also had a lower angle, and a sieve panel in front of the grid. All these studies carried out will be available in the form of scientific publications and presentations carried out at meetings and conferences as the ICES WGFTFB.

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Gear selectivity and bycatch reduction in the Norwegian Red King Crab (*Paralithodes camtschaticus*) fishery. A study on size-selective performances of different escape openings (MSc Peter Starbatty)

The aim was to investigate ways to improve the size selective performances of the fishing gear that is currently employed in the fishery for Red King Crab, *Paralithodes camtschaticus*, in Northern Norway. High bycatch rates of undersized crabs are a source of concern since these individuals have to be sorted out and discarded into the sea, a procedure that increases the risk for injuries and unaccounted mortality. Bycatch-related problems and knowledge of king crabs' behaviour in relation to fishing gear are explained in detail. Escape vents which are implemented into the side panels of the currently used rectangular pots can facilitate the egress of captured sublegal-sized animals while the pot is on the seabed and are regarded as a common tool to reduce their unintentional retention. Comparative fishing trials were carried out during February and March 2016 in the Varangerfjord in order to compare the catch compositions of traps equipped with escape vents of different shapes and sizes. Their abilities to sort out undersized crabs while keeping legal-sized ones inside the gear have been analysed by running Kruskal–Wallis H-tests. The results of these experiments did not reveal one of the tested escape openings to be superior to the others in all terms, though certain tendencies are recognizable.

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Bycatch reduction in the Northeast Atlantic shrimp fisheries

Currently, there is a great interest in improving bycatch reduction in the Norwegian shrimp fisheries and joint efforts by the fishing fleet, the Fisheries Directorate and science started recently. The aim is to reduce bycatches well below today's strict regulations on legal numbers of fish counted as bycatch. At the Arctic University of Norway we have initiated a set of experiments to document the effect on various bycatch species and sizes (including shrimps below minimum landing size). In these trials we implement new installation procedures for the compulsory Nordmöre grid, new guiding panel installation, we examine the effects of square mesh panels in the codend, extra sorting grids and various simulators (like LED). By the end of 2016 we managed to get a US $ 1,2 million funding from the Norwegian Seafood Research Fund for a 3-year project (2017-2019) on improved shrimp trawling. Our participants are SINTEF, IMR and Møreforskning.

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Improving catch efficiency by changing groundgear design: Case study of Northeast Atlantic cod (*Gadus morhua*) in the Barents Sea bottom-trawl fishery

The aim of this study was to determine if catch efficiency for cod (*Gadus morhua* L.) in the Barents Sea bottom-trawl fishery could be improved by replacing the conventional rock-hopper groundgear with a new type of groundgear called semicircular spreading gear (SCSG). Based on experimental fishing conducted in 2014 and 2015, we quantified the escape rate of cod beneath the fishing line of the trawl for each of the two groundgears and thereby obtained a measure for the groundgears' catching efficiency. Fish escapees were collected in a retainer bag attached to the fishing line of the trawl and behind the groundgear, and its catches were compared with those in the trawl codend. A significant improvement in the catch efficiency was found for the SCSG relative to the rock-hopper gear for cod between 56 and 105 cm, as significantly fewer cod escaped under the trawl equipped with the new groundgear. The results demonstrated that groundgear efficiency was length dependent for both groundgear types, as both showed increasing efficiency with increased fish length. The average catch efficiency for cod above 56 cm increased 9.19%–22.4% (depending on the herding efficiency) with the SCSG compared to the rock-hopper, which corresponds to a reduction in the escape rate of 57.1%–61.73% (depending on the herding efficiency). This study demonstrates that improved catch efficiency can be obtained by substituting the conventional rock-hopper gear with the newly developed SCSG without increasing trawl dimensions.

Contact: Jesse Brinkhof (jesse.brinkhof@uit.no)

Size selection of redfish (*Sebastes* spp.) in a double grid system

We inserted a new double steel grid system consisting of a lower and an upper grid in a four-panel section to increase the cross sectional area and improve the size selectivity in the Norwegian bottom-trawl fishery. We tested its ability to size select and release a typical bycatch species in the cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinnus*) directed fishery (i.e. redfish (*Sebastes* spp.). The redfish selectivity data were analysed using a new model that included direct quantification of the probability that fish will make contact with the grids. The results showed that redfish escaped mainly through the second (upper) grid. The release efficiency of the first (lower) grid was significantly lower than that of the second grid because a substantially smaller fraction of the redfish entering the grid zone made contact with it. An estimated 80% of the redfish made contact with at least one of the two grids. However, the release efficiency and overall size selection for redfish of the new double grid system was not significantly better than those of the grid systems used in the fishery today. Moreover, we estimated that the existing Sort-V single grid system releases significantly more redfish than the new double grid system.

Contact: Roger B. Larsen (roger.larsen@uit.no)

Assessing possible selection in the codend during buffer towing of cod (*Gadus morhua*)

Due to the high abundance and density of cod (*Gadus morhua*) in the Barents Sea, a new practice has appeared among trawlers, termed buffer towing. The rationale for this practice is to avoid any stop in the onboard factory by deploying the trawl directly after taking a catch onboard. In many cases this results in that the approximate amount of catch is caught before the catch from the previous haul is processed, resulting in buffer towing. During buffer towing, the trawl is lifted from the seabed so the catching process stops. The trawl with the catch is then towed midwater at low speed until the production capacity in the factory onboard is restored. However, enforcing management authorities have claims that catches that have been buffer towed contain conspicuously fewer undersized fish, as well as fish floating behind vessels that buffer tow. This practice could therefore possible contribute to unaccounted fishing mortality. Our aim was therefore to investigate if any selection process finds place during buffer towing. The results from a 20 hauls proved that there may be a high length dependent escape rate of cod during buffer towing, both above and below the minimum landing size.

Contact: Jesse Brinkhof (jesse.brinkhof@uit.no)

Assessing the impact of buffer towing on the quality of the catch

Buffer towing (also called for "short wiring") is a method often applied during conditions with high densities of fish, as currently encountered in Barents Sea. However, this practice has caused some concern, both from the fishing industry, due to indication of reduced catch quality. Therefore, we wanted to document the effect of buffer towing on the catch quality. In total 600 cod were sampled from 20 hauls, alternating between taking the catch directly onboard, and buffer towing. The buffer towing was conducted for 60 minutes, at a depth equivalent to 40% reduction in the ambient water pressure of the maximum depth. From each haul cod (n = 30) were collected from the codend and immediately stunned with a blow to the head. Blood samples were taken from 10 fish in order to measure levels of lactate and glucose. All 30 fish were bleed and kept in running water for 30 minutes before gutting and heading. All fish were block-frozen for later analysis of filet index and catch damage index. The fish was thawed in freshwater (1°), before conducting the sensory evaluation of the catch quality. The Catch Damage Index (CDI) was applied to evaluate gear related damages, bruises, bleeding and skin damage in a scale from 0 to 2, where 0 is flawless, 1 is moderate, and 2 is severe. Then the fish was filleted by hand and a fillet index was applied on both fillets evaluating fillet gaping, colour, texture and surface. Finally, the fillets were measured instrumental using hyperspectral images to objectively measure the amount of residual blood in the fillet. The current result indicates a significant difference in the levels of glucose, bleeding, as well as fillet colour. This indicates that prolonged buffet towing has a negative effect on the catch quality. Contact: Jesse Brinkhof (jesse.brinkhof@uit.no)

Snow crab in the Northeast Atlantic – a possible conflict between crab potting and established trawling for groundfish and shrimp

Currently, there is a great interest in mapping the distribution and demography of the invasive snow crab (*Chionoecetes opilio*). At the Arctic University of Norway, we participate with three research institute to collect data by ordinary and modified crab pots and bottom trawls. During our fish and shrimp trawl studies in the Northeast Atlantic we have over the last years added bags behind the fishing line to collect escapees (fish and crabs). During February and November 2016 we used a re-designed version of these bags and improved the catchability of them. Thousands of snow crabs of Sizes 12–148 mm carapace width were collected with "retainerbags" during 2016. The data will also be used to examine if bottom trawling will cause damage on the snowcrab and to describe how a new type of fishery evolves in an area where trawling for shrimps and trawling (and longlining and demersal seining) for fish is established. Furthermore 2 MSc students are currently working on trawl-pot issues and data on fecundity.

Contact: Roger B. Larsen (roger.larsen@uit.no)

11.14 Canada

11.14.1 Fisheries and Marine Institute of Memorial University of Newfoundland

Emerging Fishery – Porcupine Crab:

In 2016, a two-week study was conducted aboard a 30.5 m commercial gillnet fishing vessel (*FV Arluk I*) in NAFO Division 0B. The primary focus was to collect information on the distribution Porcupine Crab (*Neolithodes grimaldii*) using a towed benthic camera sled. Water depths were very deep, ranging from 400 to 1400 m. A total of 22km were transected. Video analysis is currently underway. Contact Scott Grant (Scott.Grant@mi.mun.ca).

Invasive Green Crab – Optimizing Capture Efficiency:

European green crab (*Carcinus maenas*) is a notorious invader on the east and west coasts of Canada. In 2016, we completed a two-year study using stationary underwater video cameras attached to Fukui traps to study parameters critical to informing the design of an optimal removal program, including rate of crab accumulation in traps, length of time to saturation, the mechanism of saturation, and whether there are differences in these parameters across distinct populations. Contact Brett Favaro (Brett.Favaro@mi.mun.ca).

LED Lights – snow crab pots

In partnership with Hampidjan Canada Ltd. and Fisheries and Oceans Canada, this project is investigating the potential benefits of adding small low-powered LED lights (Lindgren-Pitman) to snow crab traps. Laboratory experiments were completed to investigate the behaviour of snow crab toward various colours of lights. Sea trials in 2016 demonstrated that that cpue of baited traps could be enhanced by as much as 77% depending on the colour and soak time utilized. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Baited Cod Pots:

A two-year study was recently completed in partnership with harvesters in Fogo Island, Newfoundland to improve baited pots for Atlantic cod. We documented the catch rate and length selectivity for five different pot designs. Our findings showed that all designs were effective at catching cod, but that the modified NL pot with 4 entrances caught the most per deployment. This design caught 2.4 times as many fish per deployment as the standard NL pot, demonstrating that modest modifications to potting gear can have a substantial impact on catch rates. We also found that increasing mesh size was highly effective at reducing the number of undersized fish caught in the Norwegian cod pot design. Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).

Biodegradable Gillnet:

A small pilot study was initiated in 2016 to evaluate the performance of biodegradable gillnets in cold Newfoundland waters. This longitudinal study is monitoring the change in breaking strength over time for traditional nylon and biodegradable gillnet stored in flow through tanks using untreated unfiltered seawater. Preliminary results have shown no detectable change in breaking strength after a period of 6 months. Contact: Terry Bungay (Terry.Bungay@mi.mun.ca).

Quickline Technology:

A collaboration has been initiated with Fjardanet, Hampidjan, and the Marine Research Institute (Iceland) to evaluate the performance of Quickline technology. The technology replaces traditional riblines of a bottom trawl. By their design, they can be quickly removed in order for panels of netting within the trawl body to be replaced if needed. Flume tank observations are currently underway. Sea trials are planned for later in 2017. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Selective Redfish Trawl:

A five-year project was initiated in 2017 to develop a size-selective and species-selective trawl for the emerging redfish (*Sebastes* spp.) fishery in the Gulf of St. Lawrence, Canada. The project is a collaboration with the Marine Research Institute, Massachussetts Div. of Marine Fisheries, Merinov, and Hampidjan HF. The project will evaluate the efficiacy of T90 mesh and Quickline Technology for improving selectivity. Contact Paul Winger (Paul.Winger@mi.mun.ca).

11.14.2 Merinov - Centre d'Innovation de l'Aquaculture et des Pêches du Québec

Development of a multi-level trawl for the study of bycatch and northern shrimp vertical distribution for the optimization of the shrimp trawl in Quebec's fleet:

The main objective of this project is to develop a multi-level trawl in order to collect data on the vertical distribution of problematic bycatch species and northern shrimp in the commercial trawl. The study included three steps: 1) the conception of a multi-level trawl subdivided in three vertical sections; 2) the sea trials (adjustments of the device and sampling methodology); and 3) the realization of a workshop with the industry and experts. The preliminary results showed that the last 4.2 m of the shrimp trawl is in inefficient in catching shrimp, and that bycatch species, depending on the species, are mostly distributed in the lower and middle sections of the trawl. A second phase for large-scale sampling is planned, to further develop an innovative commercial trawl (phase 3), aiming to reduce the vertical opening and develop exclusion devices for bycatch. Contact Marie-Claude Côté-Laurin (marie-claude.cote-laurin@merinov.ca).

Development of a new pelagic trawl for redfish fisheries to mitigate bycatch and improve size selectivity of redfish

We are preparing a project about redfish fisheries in the Gulf of St. Lawrence, to be ready for the reopening in 2–3 years. The main objective is to propose a pelagic trawl for this fishery to be able to avoid bottom contact and bycatch of flatfish. The second objective is to improve size selectivity inside the trawl with meshes size and orientation and grids systems tests. Contact Damien Grelon (Damien.grelon@merinov.ca).

LED lights: snow crab pot in Québec north shore

A small project to test low-powered LED lights (Lindgren-Pitman) with usual bait under commercial fishing conditions. This project is conducted in collaboration with l'Office des Pêcheurs du Crabe des Neiges de la Zone 16. Contact Jean Reynaud (jean.reynaud@merinov.ca).

Hookpod: avoid bird capture in longline during deployment operations

Bird capture in longline halibut fisheries is a problem for species protection and fish capture. This project is for testing technology developed by Hookpod with a pressure dependant system which releases a hook from a cage. This technology is used in pelagic longlining and needs to be adapted to bottom-set longlines. Contact Jean Reynaud (jean.reynaud@merinov.ca).

Small-scale fisheries: Improvement in fishing yields for common crab and spider crab traps

These two relatively recent fisheries in Quebec require some improvements to increase trap performance. For crab, the incidental catch of lobsters in traps, a predatory species, is detrimental to the capture of crab. A selectivity device will be tested at the entrance to the traps. This should allow entry to crabs but not lobsters. In the case of the spider crab, the fishers use different types of traps that initially served for other species and which perform more or less well. It is therefore a question of experimenting with different forms of traps and trying to maximize their performance and thus obtain a more satisfactory catch rate. Trials at sea and follow-ups with underwater cameras are scheduled for the summer of 2017. Contact Lise Chevarie (lise.chevarie@merinov.ca).

Smart gear: turbot gillnet innovation

This two-year project aims to reduce bycatch in the commercial monofilament gillnet fishery, including the threat to 12 endangered, endangered and threatened species (and 11 additional species assessed by COSEWIC). It also aims at making modifications to the fishing gear in relation to the requirements of the MSC certifications envisaged for these fisheries and thus to improve the quality of the fish caught for marketing purposes. Contact Stéphanie Pieddesaux (stephanie.pieddesaux@merinov.ca).

Safety design criteria of working stations like pots hauler and supporting rack onboard lobster boats in Quebec LFA:

Since 2012, an important research program concerning lobster boat crew safety was undertaken in the Quebec Gaspe Peninsula and Magdalen Islands fisheries. In cooperation with Laval University ergonomists, we analysed the risks and determined factors involved in overboard falls; we documented collective and individual prevention solutions that can be adapted to lobster boats; and we identified, with the most promising risk reduction scenarios. In 2015, we developed, tested at-sea, and implemented practical integrated technical solutions for the pot hauler and the supporting fishing lines rack. Both of these are most used by crewmen for easing their work. Attention has been paid to reduce ropes entanglement risks and body efforts when hauling and launching the fishing gear. Results are currently under analysis. Contact Francis Coulombe (francis.coulombe@merinov.ca).

11.14.3 Fisheries and Oceans Canada

Multispecies Surveys – Monitoring gear survey bottom contact:

Determining on-bottom fishing time or tow duration is critical for estimating bottom trawl swept-area for survey indices which are used in stock assessment. Fishing depth from a Conductivity-Temperature-Depth (CTD) Instrument mounted on the square of the trawl has been used to determine fishing time by interpreting the rate of depth change to both initiate and complete survey tows. Data from a bottom contact sensor would not only improve accuracy for estimating tow duration (as using depth can be ambiguous with topographically diverse bottom types) but will also provide an estimate of bottom contact time of the footgear -critical both for determining a successful tow and the effective swept-area. We conducted limited testing of a SCANMAR hydroacoustic bottom contact sensor attached directly to the centre of the footgear of the Campelen 1800 shrimp trawl during the Northwest Atlantic Fisheries Centre (NAFC) 2016 fall surveys aboard the research vessel *CCGS Teleost*. The primary focus was to verify the extent of bottom contacted as confirmed by a clearance value of zero (clearance data comes from the SCANMAR trawl sounder which has been used to monitor bottom contact of the survey trawl). Our preliminary observations ($n = 28$) have shown a reasonable agreement between clearance data and bottom contact angle data. The attachment of a bottom contact sensor should deliver more practical information on tow duration and contact, particularly for deep-water tows (up to 1500 m), when often there is a failure of recording bottom clearance data from the trawl sounder. Further testing of the bottom contact sensor is anticipated during the upcoming spring survey aboard the research vessel *CCGS Alfred Needler* in May 2017. Contact Truong Nguyen (Truong.Nguyen@dfo-mpo.gc.ca).

11.15 Italy

11.15.1 National Research Council (CNR) - Institute of Marine Sciences (ISMAR) – Fishing Technology Unit, Ancona – Italy

Antonello Sala, Sara Bonanomi, Joana Buoninsegni, Alessandro Colombelli, Fabrizio Moro, Emilio Notti, Jacopo Pulcinella

Project EU-BENTHIS

BENTHIS (Benthic ecosystem fisheries Impact Study) is a five-year project, aiming at integrating the role of marine benthic ecosystems in fisheries management. The European Union has funded the Benthis project to provide the urgently needed knowledge to support an integrated approach to the management of human activities in the marine environment, in particular fishing. Main objectives of the project are:

- the assessment of different marine benthic ecosystems status;
- the development of tools to assess effects of bottom trawling on the structure and functioning of EU benthic ecosystems;
- development and testing, in close collaboration with fishing industries, of innovative technologies that reduce the impact of trawl fisheries on the benthic ecosystem;
- development of sustainable management plan in order to reduce the impact of fishing and quantify its ecological and socio-economic consequences, together with the fishing industry and other stakeholders on a regional scale.

The activities carried out for the Mediterranean case study focused on the evaluation of the performances of experimental otterboards and on the design and test of some innovative modification of the bottom trawl. Finally, a technical tool for evaluating the physical impact of bottom otterboards was designed and tested, by implementing Sid-scan sonar technology and a turbidity meter.

Novel otterboards

Two italian door manufacturers, involved in the project as SMEs, developed two innovative otterboards aiming at reducing the pyhisical seabed impact, using as a reference the Thyboron VF15 pelagic otterboard. A complete cycle of tests has been deployed, including facilities tests in wind tunnel and flume tank and sea trial onboard the RV and a commercial bottom trawler.

Based on a preliminary data check (see Table 11.15.1).

Table 11.15.1. Sea trials onboard fishing vessel – July, 2014. (HDS[m] horizontal door spread; HNO[m] horizontal net opening; VNO[m] vertical net opening; TS[kn] trawling speed; TTF[kg] total towing force; G-Ar-Poly and G-Fly: traditional and experimental doors from "Grilli sas"; M-Z and M-Biplan: traditional and experimental doors from "Mori Carlo srl").

	HDS [m]	HNO [m]	VNO [m]	TS [kn]	TTF [kg]	TP [kW]	HDS/TTF [m/kg]	HNO/TTF [m/kg]	VNO/TTF [m/kg]
G-Ar-Poly	44.06	16.48	0.78	3.71	3566	66.73	1.24	0.46	0.02
G-Fly	59.00	18.59	0.68	3.41	3316	57.04	1.78	0.56	0.02
M-Z	50.90	19.19	0.64	3.57	3455	62.22	1.47	0.56	0.02
M-Biplan	51.01	18.21	0.73	3.58	3415	61.67	1.49	0.53	0.02

Development and test of a switch panel to increase selectivity in bottom-trawlnets

Some relevant modifications on the design of a typical bottom-trawlnet was tested in February and October and 2016. One of the nets of a twin trawl fishing gear has been modified in central part, in order to compare net openings and catch for each haul carried out. More in detalis, according to a preliminary project from TECNOPESCA (Spain), and further development by TECNOPESCA Italy, a switch panel was mounted in the funnel of one of the nets. Side panels at the same level of the stiwh panels were made with same net type of the codend (Figure 11.15.1). The fish are thus forced to move near the side panels before entering in the codend, increasing the probability of escapement of juveniles.

Catch comparison and selectivity analysis will allow for a complete evaluation of the efficiency of such modifications. Furthermore, the implementation will be evaluated from the energy efficiency perspective.

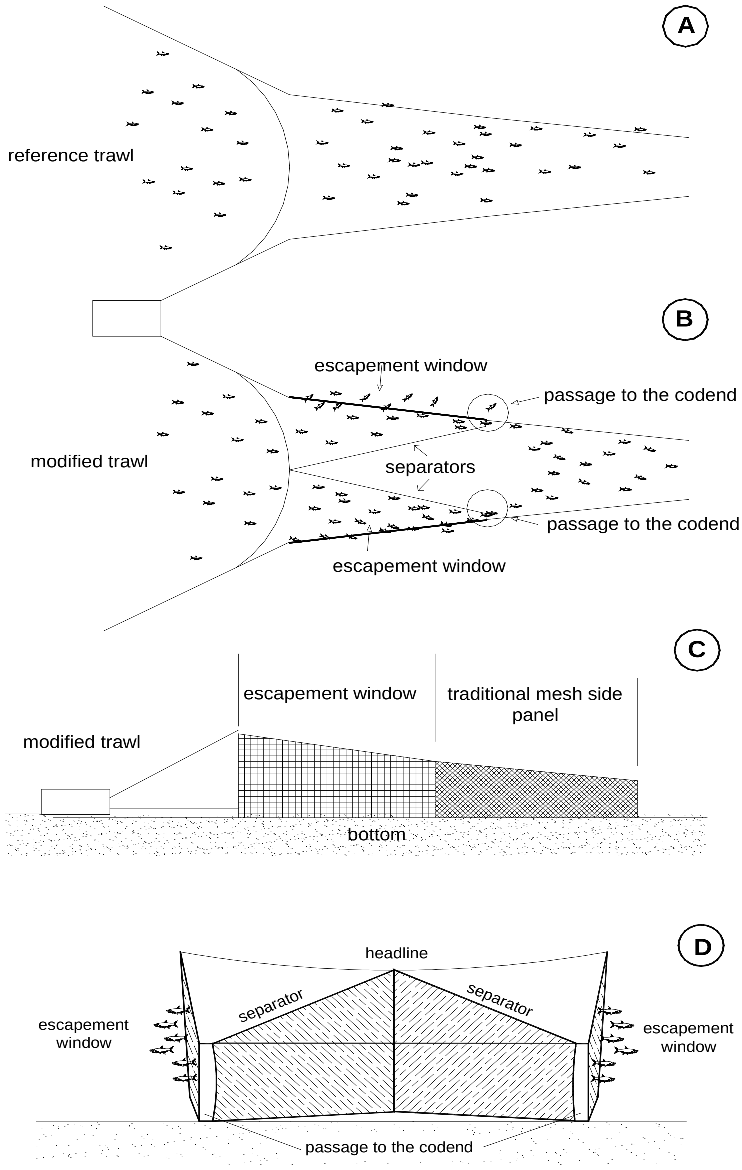

Figure 11.15.1. Schema of the modified twin trawls. One of the twin trawls (A) represents the reference in catches and geometrical and mechanical characteristics such as net openings and drag resistance. The other twin trawl will be used for the implementation of the selector device (B). The selector device consists of two separator panels, which carry the fish near the side panels of trawlnet. The side panels along the separator panels will be provided of an escapement window (C) proper mesh size and configuration to guarantee the escapement of juveniles and other unwanted catches. At the end of the separator panels, through two passages (D) fish will proceed along the net until the codend.

Evaluation of the capture efficiency and size selectivity of small prawn pots for the species *Melicertus kerathurus* in the Northern Adriatic Sea

The caramote shrimp is a common Mediterranean shrimp that lives on soft bottoms, usually in waters shallower than 60 m deep. It is usually efficiently caught mainly with bottom trawls and fixed set-nets by artisanal fishery, but its presence was recorded in baited traps as well. Here we examine the capture efficiency and the size selectivity of an experimental baited trap characterized by a commercial mesh of 20 mm length. Overall 50 traps were prepared, 25 with commercial mesh of 20 mm and 25 control traps with smaller mesh of 8.5 mm. The experiment will take place in Senigallia, in Adriatic coast (GSA 17) from April–May 2017, a favorable season for the target species of interest.

The traps will be randomly arranged on two longlines and on each longline they will be 25 meters distant from each other. Traps will be randomly mixed on each longline to ensure that they are catching the same population. Since we expect different species to enter the traps, we will also examine the effects of mesh size on the catch composition and size distribution of the species caught. We plan to collect operational and biological data, including catch composition, lengths and weights for all species, haul times and locations, pot type, weather conditions and depth. We will finally create a model to explain the experimentally obtained data and we'll use it to evaluate the capture efficiency and predict the selectivity of the 20-mm mesh. With this experiment we try to evaluate the potential of baited traps as a responsible alternative to current commercial fishing gears, due to higher species selectivity, low impact on benthic ecosystems and low operational costs.

Assessment tool for evaluating the physical impact of bottom otterboards

In order to evaluate the physical impact of bottom otterboards, a methodic approach was designed, based on Sid-scan sonar technology and through a turbidity meter (Figure 11.15.2). The aim was to evaluate the volume and density of resuspension plumb and to relate it to otterboards drag.

Sid-scan sonar sonograms were analysed to evaluate the geometry of the plumbs generated by otterboards, assuming the volume as a ellypsoid. In the sime time the measurement of sediment resuspention was used as densitiy measurement. The combination of these information allowed for a rank o the otterboards based on the impact generated.

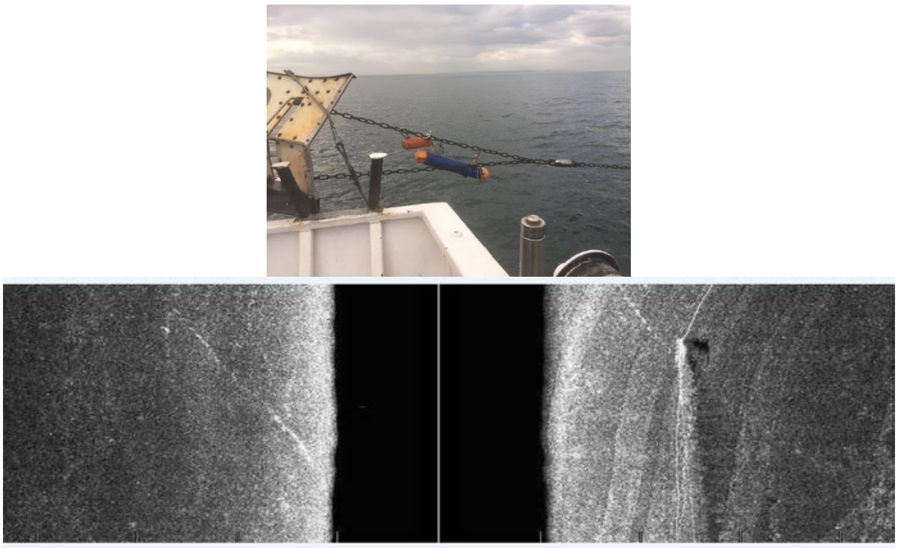

Figure 11.15.2 Monitoring of the resuspended material due to otterboards interaction with the seabed, trhough turbidity meter, connected to the backstrop of the otterboard. During trawling, Sidescan sonar monitoring allowed for a geometric evaluation of the plumb of resuspended sediment.

Project EU-Life+ EFFICIENTSHIP

The EfficientShip project (LIFE13 ENV/FR/000851) will demonstrate the efficiency of an innovative ORC technology for reducing the GHG emissions of thermal engines. The project challenges are:

1. To adapt an innovative heat recovery technology (ORC) to mobile thermal engines, allowing the reduction of between 5 and 10% of the GHG emissions.
2. To raise awareness of the European fishing sector on the importance of the reduction of the vessels GHG emissions in a context of global warming and to offer them some simulation on the adaptation of the EfficientShip innovation on their vessels.

Case study 1

An Irish vivier crabber has been selected for the implementation of the ORC system. The electrical energy produced for water pumps will be supplied by the ORC system in order to reduce the load of auxiliary engines. The reduction on engine load will determine a reduction in fuel consumption and in GHG emissions. The ORC system will recover the heat by the exhaust gas pipe of the main engine and the remaining heat will be discharged by the heat exchangers of the vessel.

Sea trials have been conducted in the period April-June 2016. A fuel consumption monitoring system has been tested and data collected were analysed for preliminary assessment of fuel usage of auxiliary engines devoted to electrical power generation.

Case study 2

A bottom otter trawler operating in Adriatic Sea was involved in the project since september 2016 as the previous irish vessel was no longer available due to technical issues occurred during the installation of the ORC system and to reluctance of the owner. The mission and operative profile of the new vessel is different thus the monitoring procedure and systems are now different. Nevertheless, the general protocol for the evaluation of the impact of the ORC system has been confirmed. The impact of the implementation of ORC technology in fisheries to save fuel will be evaluated from technical and economic perspective. A socio-economic impact evaluation was started with the aim to assess cost benefit analysis and potential scenario including the entire Adriatic bottom-trawler fleet. More info at: www.efficientship.eu

Italian National Project BYCATCH VII

The project is an extension of previous monitoring programmes (BYCATCH I, II, III, IV, V and VI) of accidental catches of cetaceans in Italian pelagic trawlers in the northern central Adriatic Sea and in the Sicilian Channel. The programme is funded by the Italian Ministry of Agriculture, Food and Forestry, in compliance with Regulation (EC) No. 812/2004. Under this regulation, 'Member states shall design and implement monitoring schemes for accidental catches of cetaceans […]'. The programme also includes monitoring of other species of conservation concern such as sea turtles and elasmobranchs which are considered vulnerable species to commercial fishing.

The main objectives of the project are listed below:

- training of fisheries observers;
- evaluate the presence/absence of cetaceans during fishing operations on board pelagic trawlers;
- data collection of accidental catches of cetaceans and species of conservation concern (sea turtle and elasmobranch) on board pelagic trawlers;
- tissue sampling of cetaceans, sea turtle and elasmobranch for genetic and stable isotope analysis;
- create a database for data management;
- evaluate accidental catches of cetaceans in the northern central Adriatic Sea at population level (population genetic analysis);

- evaluate the acoustic behaviour of cetaceans using specific bioacustic field techniques during fishing operations;
- investigate the group structure, movement patterns and site fidelity of cetaceans with photo-identification of individuals'dorsal fins;
- test mitigation measures (grids and innovative acoustic devices) to minimize bycatch of protected species and species of conservation concern in pelagic trawl fisheries;
- identify the distribution and movement patterns of different elasmobranch species accidentally taken during pelagic trawl fisheries operations by recording geo-referenced data (mark-recapture method);
- discuss together with local authorities a management plan for bottlonose dolphin (Tursiops truncatus) in the Adriatic;
- attend the ICES Working Group on Bycatch of Protected Species (WGBYC);
- write annual reports.

Between March and December 2016, seven independent fisheries observers monitored 174 fishing trips on board pelagic trawlers in the northern central Adriatic Sea. 251 sighting of bottlenose dolphins (Tursiops truncatus) have been recorded during all fishing operations. A number of bycatch records of species of conservation concern was recorded. Specifically, elasmobranchs represented the majority of the bycatch. Indeed, spiny dogfish *Squalus acanthias* (45), blackspotted smooth hound *Mustelus punctulatus* (18) and smooth hound *Mustelus mustelus* (17) were the most commonly caught species. In addition, 4 loggerhead turtles *Caretta caretta* and 95 twaite shad *Alosa fallax* were also reported. A database in MySQL containing all data collected by all fisheries observers and an online platform are under construction. Genetic and stable isotope analysis of 56 tissue samples of sharks (34 *Squalus acanthias*, 10 *Mustelus mustelus* and 12 *Mustelus punctulatus*) are currently in progress. Direct evaluation of interactions between cetaceans and fishing operations is ongoing by testing the effectiveness of acoustic deterrents and identifying dolphin vocalizations. Sea trials for testing mitigation measures are planned for next May 2017.Further monitoring activities (approximately 40 fishing trips per month) are expected in the northern central Adriatic Sea and Sicilian Channel until the end of August 2017.

FVMS DATALOGGER

A new Fishing Vessel Monitoring System (FVMS) has been implemented to automate and make it unmanned the data acquisition from different devices (GPS, fuel consumption sensor, torsiometer, echosounder and other measurement systems) equipped on several fishing vessels monitored by CNR in Adriatic Sea. The system represents an evolution of previous monitoring system conceived at CNR by 2008 (i.e. ESIF project, Cor-fù system, see Sala *et al*., 2011).

The system can be interfaced with different communication protocols such as NMEA and Modbus. One of the main feature of FVMS is the ability to overcome typical problems occurring during data acquisition on board by unmanned systems, reducing disruption for crew on board and increasing consistency, availability and frequency of data gathering.

The core control units are based on Rasperry technology, which allows to manage different signal inputs, store data in a local micro-SD and create an automatic transfer data procedure.

Main modules of the software are listed below:

- A GPS module, which is the main module: it acquires the vessel geo-data, it manages the system time, which allows the synchronization between data from different devices (coordinates, consumption data, etc).
- a data registration module for each device with the task to query the measurement units and save data;
- a communication module, to managing the Internet connection and data transfer;
- a MySQL module to managing the communication between software and a local MySQL database.

The data are collected in MySQL format as a table where each record reported date, time, speed, coordinates, fishing trip and all the values of the connected devices (consumption data, torsiometer data, etc).

The system has a remote service for changing settings and for software update. It is equipped with WiFi and mobile adapters. The software is instructed to create WAN connection and to exchange stored data with the local server when a network is available.

Data acquired are analysed for several applications such as the estimation of vessels fuel consumption (at fishing trip base), the identification of fishing hauls and then the estimation of fishing intensity.

11.16 Japan

11.16.1 Kagoshima University

Keigo Ebata (Report compiler) (ebata@fish.kagoshima-u.ac.jp)

The effect of towing time for blood lactate level of fish caught by bottom trawl

In Japan, bottom trawl is an important fishing method, because the catch product of bottom trawl is 25.7% in the total product in 2014. The purpose of this study was to clarify the relationship between towing time and stress of fish caught using a bottom trawl. The research operations for bottom trawl were conducted from May to October 2015. Towing speed was 2 kt. Operation condition was as follow; (1) towing time of touching seabed of the trawlnet was 10 minutes, (2) towing time of touching seabed of the trawlnet was 10 minutes and not-touching seabed of net was 30 min, 1 h, 2 h and 3 h. Depth sensors for measuring depth at 1 second interval were connected to the middle of the head and groundropes. After catching, fish were picked up and taken blood from the tale. Blood lactate levels were measured with Lactate Pro portable analyser. The effects of towing time for lactate level of fish caught by bottom trawl is different for species. The lactate level of fish was divided into two groups; one was increasing with D/BL (towing distance per body length), the other was kept around 10 mmol/L. The former species included Bothidae, Mullidae, and the later included Scorpaenidae and Branchiostegidae.

Model experiment on reduction of hydrodynamic force acting on beam trawl

This study aimed to reduce the hydrodynamic force of beam trawl for energy saving. The total length of the trawl was 21.7 m (headrope: 11.6 m, groundrope: 18.2 m). The beam length was 7.5 m with the diameter of 10–15 cm. Model experiments were conducted in a flume tank according to Tauti's law. One-seventh scale model net was used. Flow speed of the tank was 0.32–0.95 m/s which equivalent to the prototype being towed at 1.5–3.0 knots at sea. Tension sensors were connected both of warps and measured the tension force at 20 Hz for 20 s. The heights were measured at the tip and center of wing net, mouth and center of body net, and codend. As a result of model experiment, hydrodynamic force acting on beam was estimated to account for 44.0% of the total hydrodynamic force acting on beam trawl. We tried to reduce the hydrodynamic force acting on beam by covering the beam with tent cloth. Model experiment on hydrodynamic force acting on beam was conducted in the flume tank. The hydrodynamic force acting on beam was measured using three component load cell at 100 Hz for 20 s. The length of tent cloth was changed from two times to ten times of the beam diameter. The hydrodynamic force acting on the beam covered with tent cloth was estimated to reduce to 69.3–73.4 % at 0.79–0.95 m/s compared to the beam without tent cloth.

11.16.2 Nagasaki University

Yoshiki Matsushita(Report compiler)(yoshiki@nagasaki-u.ac.jp)

Evaluation of catch performance of omena *Rastrineobola argentea* seine fishing in Lake Victoria, Kenya

Omena *Rastrineobola argentea* is one of the important commercial fish which accounted for approx. 50% of the total catch in Lake Victoria, Kenya. This species is mostly captured by seine fishing using fish attraction lighting rafts in night-time. This study aims to evaluate the catch performance of this fishing by taking influences of boat types, lunar phases, fishing seasons, and relevant factors into account for better fisheries management.

The study was carried out in two fishing communities outside Winam Gulf, Kenya between June 2014 to May 2015. Paddled boats and motorized boats (4 boats in total) were monitored. And their daily catch results (times of shot and hauled, catch in number of bucket) and fishing positions were recorded by a GPS logger. We analysed the catch results in relation to boat types, lunar phases, fishing seasons and communities, through Generalized Linear Model (GLM) analysis. During the survey, amount of omena caught by each boat were 18~80 tonnes for an average of 270 days. Fishing effort of paddled boats ranged from 1 to 2 hauls/day while motorized boats were about 1 to 29 hauls/day. Results of GLM analysis indicated that the most appropriate model expressing omena catch included boat types, fishing seasons, and lunar phases. The estimate indicated that daily catch by using motorized boats were 2.7~3.8 times higher than paddled boats. On the other hand, paddled boats tended to catch more fish than motorized boats when comparing a haul catch. It could be considered that under the influences of lunar phases and seasonal change, the catch of omena by paddled boats was higher than motorized boats per haul, while motorized boats caught more for a whole day because of the mobility.

Long-term catch trends of trapnet fisheries set along Tsushima Current

The study aims to analyse the relationship between Catch of three large-scale trapnet fisheries (known as a set-net in Japan) along the Tsushima Current and environmental factors. Daily catch data of Uonome (Goto-retto islands, 1993–2014), Hakozaki (Iki islands, 1985–2013) and Kayoi (Yamaguchi, 1964–2012) fishing grounds was used to extract the major captured species in each ground. SST (Sea Surface water Temperature) data of the Northeast East China Sea and the Southwest Japan Sea and index of the strength of Tsushima Current were obtained from Japan Meteorological Agency website (http:// www.data.jma.go.jp). General additive modelling (GAM) was performed to express the relationship between catch and environmental factors.

In Uonome, *Todarodes pacificus, Coryphaena hippurus* and *Cololabis saira* were the major captured species during 1993 to 2014, while in Hakozaki, *T. pacificus,* small sized *Seriola quinqueradiate* and *Parapristipoma trilineatum* were the major captured species during 1985 to 2013. *S. guinqueradiata*, small size *S. quinqueradiata* and *Trachurus japonicas* were the major species in Kayoi during 1964 to 2012. Among the major species, *T. pacificus* has become the dominant species in Hakozaki than in Uoneme since the late 1990s; while small size *S. quinqueradiata* in Kayoi has become more dominant than in Hakozaki also since the late 1990s, suggesting that distribution of these species shifted to north. The results of GAM analysis showed that only in Hakozaki the smooth term of annual SST was significant for the major captured species. High time-resolution GAM analysis (e.g. seasonal SST) may be necessary to have more specific results.

11.17 Korea

11.17.1 National Institute of Fisheries Science

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Physical properties and fishing performance of biodegradable driftnet for yellow croaker designed to reduce ghost fishing

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A biodegradable fishing gear material, a blend of 82% polybutylene succinate (PBS) and 18% polybutylene adipate-co-terephthalate (PBAT), was developed in an effort to reduce ghost fishing caused by synthetic fishing nets lost or abandoned at sea. This study was conducted to examine the physical properties of biodegradable fishing nets and compare the fishing performance of commercial and biodegradable fishing gear for yellow croaker (*Larimichthys polyactis*). The results of this study verified that the biodegradable fishing net monofilament (Ø 0.284 mm) degraded after a lapse of 24 months in seawater.

There was no significant difference in catch efficiency of yellow croaker between the biodegradable and commercial fishing gears.

A quantitative analysis of greenhouse gas emissions from the major coastal fisheries using the LCA method

Contact: Hyun-young KIM (sys9318@korea.kr) (02-2017)

The greenhouse gas emission from fisheries is an important issue due to Cancun Agreements Mexico in 1992 and the Kyoto protocol in 2005. The purpose of this research is to investigate which degree of GHG emitted from the major coastal fisheries such as coastal gillnet fishery, coastal dual purpose fishery, coastal pots fishery and coastal small-scale stow net fishery. Here, we calculated the GHG emission from the fisheries using the LCA (Life Cycle Assessment) method. The fuel use coefficients of the fisheries are also calculated according to the fuel type. The GHG emissions from sea activities by the fisheries will be dealt with. Furthermore, the GHG emissions for the unit weight of fish are also calculated with consideration to the different consuming areas.

Catching efficiency of the whelk pot in accordance with the pot materials in the Uljin waters, East sea

Contact: Heui-Chun An (anhc1@korea.kr) (02-2017)

This study compared the catching efficiency of drum type whelk pots that are made of biodegradable nets to those made of the ordinary nets, in the east coast of Korea. Compared to the conventional pots, the pots with biodegradable nets on the body or entrance part had slightly higher catch rate for both the target species and the by-catch. There is no significant difference in catch between the pots with biodegradable nets and the ordinary nets for the target species such as *Buccinum opisthoplectum, Neptunea eulimata, Buccinum striatissimum*. Consequently, using biodegradable nets for the conventional whelk pots can reduce ghost fishing by lost gears while keeping the performance of the pots.

Size selectivity of a dome-shaped pot for Morotoge shrimp *Pandalopsis japonica* in the eastern coastal waters of Korea

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Morotoge shrimp Pandalopsis japonica is caught by pot and others in the eastern coastal waters of Korea. Comparative fishing experiments were carried out in the east coast of Korea, using the dome-shaped pots with different five mesh sizes (17.1, 24.8, 35.3, 39.8, and 48.3 mm) in order to estimate the mesh selectivity of the pot for the morotoge shrimp, *Pandalopsis japonica*. The SELECT (Share Each Length's Catch Total) analysis method was applied to the catch data. The master selection curve of the pot for the shrimp was estimated to be s(R) = exp(15.770R-10.573)/[1+exp(15.770R-10.753)], where R is the ratio of carapace length to mesh size. From the selection curves, the carapace lengths of 50% retention were 11.6, 17.0, 23.9, and 34.1 mm for 17, 25, 35, and 50 mm mesh-size pot, respectively. It means that the pots of larger mesh size allow more shrimp of small size to escape.

11.17.2 Pukyong National University

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Changes in fishing characteristics and distributions of Korean tuna purse-seine fishery by oceanographic conditions in the Pacific Ocean

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The proportion of unassociated set was higher than that of associated set. The catch proportion of yellowfin was higher in the unassociated set, while that of skipjack and bigeye was higher in the associated set. Due to vessels, fishing gears and Korean captains' high-level of skills in fishing technology optimized for the unassociated set and preference of large fish, especially large yellowfin tuna, it showed unique fishing characteristics focusing on the unassociated set. When stronger El-nino occurred, the range of fishing ground tended to expand and main fishing ground moved to the eastern part of western and central Pacific Ocean. During this season, yellowfin tuna had high cpue and catch proportion of yellowfin tuna in the eastern part also increased. As for the proportion of fishing effort by set type, proportion of log associated set was high during El-nino season while that of FAD associated set was high during La-nina season.

Dynamic Behavior and Defiormation Analysis of the Fish cage system using Mass-Spring Model

Contact: Chun-Woo LEE (cwlee@pknu.ac.kr)

ln this research, a mathematical model and a simulation method were presented for analysing the performance of the large-scale fish cage system influenced by current and waves. The cage system consisted of netting, mooring ropes, floats, sinkers and floating collar. All the elements were modelled by use of the mass-spring model. The structures were divided into finite elements and mass points were placed at the mid-point of each element, and mass points were connected by springs without mass. The computation method was applied to the dynamic simulation of the actual fish cage systems rigged with synthetic fiber and copper wire simultaneously influenced by current and waves. Here, we also tried to find a relevant ratio between buoyancy and sinking force of the fish cages. The simulation results provide improved understanding of the behavior of the structure and valuable information concerning optimum ratio of the buoyancy to sinking force.

Behavior analysis of rockfish (*Sebastes inermis*) depending on the temperature and LED lights

Contact: Hyeon-Ok Shin (shinho@pknu.ac.kr)

The mean of AMD (average moving distance) for 1 minute of rockfish depending on the temperature (10 to 30℃) was 1.0 m and the mean rates of movement was 50%. The mean AMD were 1.5 m, 1.9 m and 0.7 m in the red LED (light power: 811 mW; wavelength: 622 nm), green LED (811 mW, 518 nm) light and control condition, respectively. The mean rates of movement were 54%, 65% and 45% in the red LED, green LED and control condition, respectively.

Visual spectral sensitivity of dark-adapted rockfish (Sebastes inermis) in LED light source

Contact: Hyeon-Ok Shin (shinho@pknu.ac.kr)

The visual threshold of juvenile (n = 5; weight: 20.3 ±5.2 g; total length: 10.3 ±0.7 cm) and adult (n = 5; weight: 87.8 ±21.8 g; total length: 18.1 ±1.3 cm) rockfish with electroretinograms (ERGs) measurement (light source: 405–660 nm LEDs package) were 11.66 (log quanta/cm^2/s) and 11.81 (log quanta/cm^2/s) in 574 nm, respectively. The peak wavelength of the spectral sensitivity in the dark-adapted juvenile and adult rockfish was commonly 551 nm (series of green color).

A change of rigging method for purse-seine gear of Korea tuna purse-seine fishery in the Western and Central Pacific Ocean

Contact: Hyung-Seok Kim (pelamis@pknu.ac.kr)

This paper conducted research on identifying the process of change in fishing gear and organizing the function of periodically-used fishing gear types through net plan and computer simulation by selecting the design of the four types of fishing gear used for the Korea tuna purse-seiner in the Western and Central Pacific Ocean, which 1000 G/T class and whose length over all 60 m class. In the late 1980s, the length of the tuna purse gear was 1939 m and the design depth was 160 m, but currently, the length and the design depth are 2515 m and 230 m, respectively. As a result of the simulation, the expansion of the fishing gear increased buoyance, sinking force, sinking depth, surrounded area, and purse wire continuously. Recently, the maximum tension of the currently used purse wire of tuna purse-seiner is 23.5 tonnes and is close to 25.4 tonnes which is the maximum lift capacity of WS454 winch. The way to improve fishing gear should be proceeded to increase sinking speed rather than expand the size of fishing gear.

12 Other Business

12.1 Date and Venue for the 2018 WGFTFB Meeting

The location and timing of the 2018 meeting was discussed but a decision was not possible because a formal invitation from a host institute had not been received. Several weeks after the meeting a formal invitation to WGFTFB was submitted by the Technical University of Denmark (DTU AQUA), National Institute of Aquatic Resources. No other formal invitations were received.

The invitation by DTU AQUA was accepted and the WGFTFB will meet in Hirtshals, Denmark on 4–8 June 2018.

12.2 Requests from other ICES Working Groups to WGFTFB

Two recommendations (requests for assistance) relevant to WGFTFB were submitted to the ICES SharePoint, Recommendations 2016 and Recommendations 2017.

12.2.1 Request from WGBIFS

A request for advice from the Baltic International Fish Survey Working Group (WGBIFS) first came to the notice of the WGFTFB chair in October 2016 but none follow up by chair of WGBIFS for explanations on the request, then following complaint of non-responsiveness in January at the WGCHAIR meeting. At this meeting both chairs discussed and clarified part of the request.

The request from WGBIFS sought advice on the "*Standardization of pelagic fishing gear in the IBAS surveys*". The specific recommendation was: "*Because WGBIFS has not enough competence for proposing particular type of pelagic trawl, like to ask the ICES – FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) for advice, which type of pelagic trawl, incl. Rigging (e.g. type of trawl doors), would be the best for BIAS and BASS surveys in the Baltic Sea conditions.*"

The WGFTFB chair and new WGBIFS chair (Olavi Kaljuste) meet informally during the New Zealand meeting and agreed to progress this request.

This request was discussed at the WGFTFB meeting. It was agreed that the WGFTFB chair would ask Daniel Stepputtis (Thunen Institute of Baltic Sea Fisheries) to consider involvement in this request due to his extensive knowledge and experience of trawl surveys and fishing gears in the Baltic Sea. The WGFTFB chair will contact Daniel seeking his involvement and arrange a meeting between himself, Daniel, and Olavi.

12.2.2 Request from WGTC

A request for WGFTFB assistance from the Working Group on Target Classification (WGTC) was submitted in Recommendations 2016. The request was for assistance to develop better tools to verify acoustically classified targets.

At the meeting in New Zealand the Chairs of WGFTFB, WGFAST and WGTC agreed to address this request at the next Joint meeting of WGFTFB and WGFAST in 2020, with a proposed session focusing on using trawl catches to improve techniques to verify acoustically classified targets, particularly improving fish identification (by species) and length estimates.

12.3 Discussion about JFATB

Paul Winger, chair of the Joint Session of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) and the Working Group on Fisheries Acoustics Science and Technology (WGFAST), otherwise known as JFATB, started a short discussion about future the JFATB. Currently, JFATB meets for one day every third year and has been convened by the same chairs for several joint sessions. The discussion focused on the question should the joint session be discontinued or should the meeting interval change, either meeting more frequently or less frequently. The same discussion was had by WGFAST, led by the other joint session chair, Alex de Robertis.

A consensus at the meeting was to retain the frequency of the joint session, i.e. one day every three years. WGFTFB members agreed the joint session was an important opportunity to maintain and build professional relationships and to facilitate information exchange.

Paul pointed out that he and Alex had been chairs for many joint sessions and raised the possibility of introducing formal guidelines regarding the duration of service as chair. There was no formal agreement by WGFTFB members regarding service duration, although it was recognized that a change in chair was due and appropriate. Paul also advised that planning is required soon to ensure sufficient relevant topics and presentations in time for the next meeting.

Nominations were sought for a new co-chair. Mike Pol offered to act as new co-chair and he was approved by WGFTFB members. The former chair of JFATB (Paul Winger) and nominated next chair (Mike Pol) with chair of WGFTFB (Haraldur A. Einarsson) will make a new resolution for submitting to ACOM/SCIOM before next meeting of JFATB.

The next meeting of JFATB will be in 2020, and at least one of the sessions will "investigate improved methods to refine survey gear, and quantify trawl selectivity across a broad range of species and sizes". This need has been formalized by WGFAST with details located in ICES SharePoint, Recommendations 2017. The goal of this proposed session is to facilitate improved estimates of fish distribution, by size and species, and reduce uncertainty in acoustic-trawl surveys.

12.4 The manual for measuring the Selectivity

A need for WGFTFB members to rewrite and update the selectivity manual, ICES Cooperative Research Report, No. 215. Manual of methods of measuring the selectivity of towed fishing gears (1996) was discussed. While parts of the manual are still relevant, other parts are outdated due to recent key methodological developments. It is estimated that a rewrite will take approximately 2–5 years, particularly if selectivity of static gear is included as well.

It remains unclear how to progress a rewrite of the manual. Challenges include identifying individuals to participate in the rewrite, including editors, coordinating involvement and timing of participants, and addressing funding issues. This discussion will continue at the meeting next year and during communication between interested members until then via e-mail.

12.5 E-mail groups

At the meeting a new arrangement for e-mail-lists of members was explained.

Because membership of WGFTFB includes individuals from ICES Member Countries and non-ICES Member Countries, the SharePoint is not working well for announcements or requesting for information from the entire group. To solve this three e-mail groups have been established:

- wgftfb@googlegroups.com Where all WGFTFB members from ICES Member Countries and non-ICES Member Countries can be contacted, as well former members and persons interested to WGFTFB work. This is the largest list.
- wgftfb-regular@googlegroups.com Where all regular WGFTFB members from ICES Member Countries can be contacted, with specific details relevant only to members from ICES countries.
- wgftfb-invited@googlegroups.com Where individuals, usually non-regular participants from ICES countries and outside, can be contacted.

It is hoped this approach will ease the workload of the chair and facilitate communication, particularly as the number of individuals involved in the WGFTFB, as invited members and informal is rapidly growing.

12.6 Recommendations for workshop

A proposal for a workshop with recommendation to ICES (ACOM and SCIOM) was submitted at the meeting by Jordan Feekings. This was connected to protects called "Industry-led fishing gear selectivity improvements", where the aim is to accelerate the process of testing gears for compliance with sustainability performance standards as part of the Common Fisheries Policy and to increase diversity of gears being tested. As part of this process, a bottom up approach to testing would be developed, where ideas by fishers would be permitted to carry out a preliminary test of their ideas before proceeding to more rigorous scientific testing should initial results look promising. This process will also hopefully iron out the good ideas from the bad, meaning that only those solutions which achieve their objective in the industry-led pre-test will have the chance to undergo scientific testing and potential implementation into the fishery.

The proposed workshop would serve as an opportunity to investigate similar programs from elsewhere and explore how to get the most out of such programs, including the use of incentives to promote change. The proposal was well received and further development of the proposal was encouraged. Proposal details can be found in Annex 4.

12.7 Chair from FAO

This was the last year for Petri Suuronen as chair of behalf for FAO in ICES-FAO WGFTFB. The group congratulated Petri Suuronen on his pending retirement from FAO and recognized his many years of excellent service as an active member of the group and more recently as Chair of WGFTFB. Petri's readiness to contribute and inform conversation, his wisdom and insight, and his good humour, will be sorely missed by the entire group.

A new Chair from FAO will be welcomed at the next WGFTFB meeting.

12.8 Topic Groups for the 2018 WGFTFB Meeting

New Topic Group: Evaluating the application of artificial light for bycatch mitigation (Light)

A WGFTFB Topic Group convened by Noëlle Yochum (USA), Darcie Hunt (Australia), and Junita Karlsen (Denmark) will be formed in 2018 to evaluate the application of light as a mechanism for bycatch mitigation.

Terms of Reference:

1) Describe and summarize completed and ongoing research, successes and 'failures', related to the application of light for bycatch mitigation.
2) Identify patterns with respect to species and fishery/ gear types, noting fish behavior in response to light (attraction, repulsion, guidance), and other variables that play a role in the efficacy of using artificial light for bycatch mitigation (e.g. vision, depth, etc.).
3) Describe best sampling techniques for testing the application of artificial light under varying circumstances, including guidance for dealing with common experimental challenges.
4) Highlight areas of needed research in the field of fish behavior with respect to light, and fisheries that might benefit from the application of artificial light.

Justification:

Essential to the study of fishing gear design and use is fish behavior. The success of bycatch mitigation is linked with understanding how fish interact with fishing gear and respond to the micro-environment in and around the gear. A component of fish behavior that is increasingly being evaluated is the reaction of fish to artificial light. To that end, from 2012-2015, Heui-Chun An, Mike Breen, Odd-Børre Humborstad, and Yoshkiki Matsushita convened a WGFTFB Topic Group titled "Use of Artificial Light in Fishing". The focus of this Group was to evaluate the use of artificial light to affect fish behavior and stimulate catch, and to research and synthesize information on fish vision and behavior with respect to light. They also summarized the use of artificial light in fisheries globally and regionally. We aim to build on this work and extend the scope to focus on the application of light to enhance bycatch mitigation (e.g. illuminating escape ports or the footrope in trawl gear). We will synthesize research on this topic to identify patterns related to species and biological traits, and gear types and uses. We will evaluate how artificial light affects behavior with respect to attraction and repulsion, and what variables influence these relationships (e.g. vision, depth). In doing this, we aim to highlight gaps in knowledge of this topic, and fisheries that might benefit from the application of artificial light. We will also analyse completed research and utilize the knowledge of the experienced researchers in this Working Group to describe best sampling techniques, and to provide advice for overcoming challenges specific to this type of research. We hope that these meetings will also provide opportunities for an exchange of ideas, and stimulate innovation.

New Topic Group – factsheets on fishing gear selectivity and catch comparison trials (Facts)

A WGFTFB Topic Group convened by Barry O'Neill (Scotland) and Jordan Feekings (Denmark) will be formed in 2018 to develop a series of factsheets on fishing gear selectivity and catch comparison trials

Terms of Reference:

1) to review the different types of fishing gear related factsheets that have been produced and explore the possible solutions that would be appropriate to fishing gear selectivity and catch comparison trials
2) to agree on the content and on a common format and to decide what information is required to produce the factsheets. Specific consideration will be given to how these issues will affect (i) the ease with which the factsheets can be formulated and (ii) their accessibility and usefulness.
3) to produce, on an annual basis, factsheets on fishing gear selectivity and catch comparison trials, from a range of fisheries.
4) to identify the best means to disseminate and store the factsheets to ensure that they are easily accessible, both now and in future, by the fishing industry, netmakers and all relevant stakeholders.

Justification:

Many trials have taken place of novel and modified fishing gears to improve selectivity and to reduce discarding. Very often, however fishers, skippers, netmakers and fisheries managers are unaware of these developments. As a result, potential solutions to problems faced in particular fisheries may go un-noticed or resources may be wasted on trials of gears that have already be shown to be ineffective.

One way of disseminating this type of information is through accessible and easy-to interpret factsheets. The EU funded Horizon 2020 project DISCARDLESS has assembled a catalogue of nearly 70 factsheets, each of which describes the results of individual selectivity and catch comparison trials (http://www.discardless.eu/selectivity_manual). A new project, 'Trawl KnowHow', aims to provide a platform to access existing information on gear selectivity experiments.

Here we would like to further develop these types of approaches, paying particular attention to disseminating information in an accessible and easy-to interpret format and circulating it as widely as possible to fishers, netmakers and all relevant stakeholders. The ICES – FAO WGFTFB has a global membership and perspective and thus is ideally placed to both gather and disseminate this type of information. It also has the technological expertise to ensure that the factsheets address bycatch and discard issues that are being faced by the fishing industry.

Ongoing Topic Group: Contact Probability of Selective Devices (Contact)

A WGFTFB topic group of experts convened by Daniel Stepputtis (Germany) and Bent Herrmann (Denmark) will continue to investigate, understand and improve the contact probability of specific selective devices (e.g. grids, netting). It will document and evaluate current and past work regarding the influence and improvement of contact probability. This will include studies from a wide range of scientific fields, such as selectivity, behaviour, hydrodynamics and gear design. Special attention will be given to investigating how to improve the performance of gears and selective devices with suboptimal selective properties.

Terms of reference:

1) Summarize current and past work in relation to contact probability
2) Discuss and describe methods (experimental and statistical) to investigate and quantify contact probability
3) Investigate and make recommendations on how to improve contact probability in selective devices, including:

a. Identification of gears and selective devices with suboptimal contact probability (preferably based on current gear trials from group members)
b. Discussion on potential causes and solutions
c. Recommendations on experimental/theoretical work to understand and improve the contact probability

Justification:

Over the past decades, numerous selective devices have been developed and tested. Many of them did not fulfil expectations and even those that are now being used can probably be improved.

A key factor influencing the effectiveness of selectivity devices is the probability of a given specimen to contact the specific selection device. Nevertheless, this factor is often not sufficiently considered when developing selective devices. Additionally, few selectivity studies have quantified the contact probability of these devices although it underpins how they perform and how they can be improved.

This Topic Group will be highly relevant to the further development of sustainable fisheries, especially in the light of discard ban, single and multispecies selectivity and potentially also for balanced harvesting in a wider sense.

Annex 1: List of participants

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Annex 2: Agenda

	Tuesday 4 April 2017	Session
8:30-8:40	House keeping	
8:40-9:00	WGFTFB opening	
9:00-9:25	FAO briefing on relevant activities **Petri Suuronen**	
9:25-9:30	Introducing the session **Steve Eayrs**	Facilitating change in commercial fisheries: Successes, challenges, and human behavior
9:30-10:00	Change Process Structure. How to succeed with change management in challenging circumstances? **Richard Wells**	
10:00-10:30	**COFFEE BREAK**	
10:30-10:50	NPF Industry Pty Ltd – driving industry innovation to address bycatch in Australia's Northern Prawn **Adrianne Laird**	
10:50-11:10	Introducing the 'Trawl Know how' project - disseminating gear technology information to fishers **Jereon van der Kooij**	
11:10-11:30	Industry-led fishing gear selectivity improvements: Ideas and lessons learned **Jordan Feekings**	
11:30-11:50	Change readiness. How can we know if fishers are ready to change? **Steve Eayrs**	
11:50-12:10	Fisher Selectivity: The Science of How to Engage the Best Fishers for Inventing Bycatch Solutions **Lekelia D. Jenkins**	
12:10-12:30	**Discussion**	
12:30-14:00	**LUNCH BREAK**	
14:00-14:20	**NZ-session** Unwanted bycatch issues in New Zealand **Richard Wells**	New Zealand Bycatch issues
14:20-14:40	**NZ-session** Industry-led efforts to reduce catches of small fish in a mixed fishery in Hawkes Bay, New Zealand. **Emma Jones**	
14:40-15:00	**NZ-session**	
15:00-15:30	**TEA BREAK**	
15:30-15:50	Quality driven gear development: Part I Fitting the process to the fish **Suzy Black**	Gear development
15:50-16:10	Quality driven gear development: Part II Technology in operation **Gerard Janssen**	
16:10-	Australian research to reduce bycatch and improve fuel efficiency via	

16:30	Low Impact Fuel Efficient (LIFE) prawn trawls – previous work and next steps. **Steve Kennelly**	
16:30-16:50	Performance of bycatch reduction devices varies for chondrichthyan, reptile, and cetacean mitigation **John Wakeford**	
16:50-17:10	**Discussion**	

	Wednesday 5 April 2017	**Session**
8:30-8:40	Announcement / Housekeeping	
8:40-9:00	Automated valves for measuring discards in Demersal fisheries **Pieke Molenaar**	**Technology for efficient and selective harvesting of Crustaceans**
9:00-9:20	SepNep multispecies selectivity in Nephrops trawls by combining innovative sorting panels and grids **Pieke Molenaar**	
9:20-9:40	FLEXSELECT: a flexible counter-herding device to reduce bycatch in trawl fisheries **Valentina Melli**	
9:40-10:00	Utilizing differences in behavior to improve catch efficiency in the Nephrops directed fisheries **Ludvik A. Krag**	
10:00-10:30	**COFFEE BREAK**	
10:30-10:50	Selectivity in a divided codend used in the multispecies trawl fishery targeting crustaceans **Junita D. Karlsen**	
10:50-11:10	CREELSELECT: a method for selecting optimal creel mesh for Norway lobster (Nephrops norvegicus, (L.)) **Jure Brcić**	
11:10-11:30	Addressing the Challenge of Bait Intensive Fisheries: Can Alternative Baits Work in the Barents Sea **Tomas Araya Schmidt**	
11:30-11:50	Assessments of Species- and Size- Selectivity of Bycatch Reduction Devices for Shrimp Beam Trawl **Yoritake Kajikawa**	
11:50-12:10	**Discussion**	
12:10-13:40	**LUNCH BREAK**	**Means and methods to mitigate bycatch, discards**
13:40-14:00	Quantitative analysis of species selectivity of fishing gears – an ecological approach **Pingguo He**	
14:00-14:20	Avoidance of Atlantic cod (Gadus morhua) with an ultra-low opening trawl (ULOT) in the New England **Michael Pol**	
14:20-14:40	New Approaches to Seabird Mitigation in Australian Trawl Fisheries **Phil Ravanello**	

14:40-15:00	Effect of the inner netting on the physical performance of Antarctic Krill trawl **Zhipeng Su**	
15:00-15:30	**TEA BREAK**	
15:30-15:50	Survival of trawler deck-released halibut as observed with tilt-sensing satellite tags **Craig S. Rose**	
15:50-16:10	Movement range and behavior characteristics of Gadus macrocephalus in Jinhae Bay, Korea **Hyeon-Ok Shin**	
16:10-16:30	Quantifying Seabed Contact in Commercial Fishing Gear **Brianna Bowman King**	
16:30-16:50	**Discussion**	
18:00-	**Meet for transport to conference dinner at Seifried Estate Winery**	

	Thursday 6 April 2017	**Session**
8:30-8:40	Announcement / Housekeeping	
8:40-9:00	**Topic group meeting - promotions** **TOR a**.- Change Management in Fisheries (Change) **Convened by Steve Eayrs and Michael Pol**	**Topic group meeting**
9:00-9:20	**TOR b.** -Evaluation of trawl groundgear for efficiency, bycatch and impact on the seabed (Groundgear) **Convened by Pingguo He**	
9:20-9:40	Fishing effects in 3D – it's not all about bottom contact anymore **Aileen M. Nimick**	
9:40-10:00	**TOR c.** -Assessment on energy use and fuel consumption in fisheries (Energy) **Convened by Emilio Notti and Steve Eayrs**	
10:00-10:30	COFFEE BREAK	
10:30-10:50	E-Audit: Energy performance evaluation for Mediterranean trawler **Emilio Notti**	
10:50-11:10	Technological advances of fishing lamp and energy saving effect in the squid jigging fishery **Heui-Chun An**	
11:10-12:20	**Topic group meetings starts** **(Changex). (Groundgear), and (Energy).**	
12:10-13:40	**LUNCH BREAK**	
13:40-15:00	**Topic group meeting (continued)**	
15:00-15:30	**TEA BREAK**	
15:30-17:00	**Topic group meeting (continued)**	

	Friday 7 April 2017	Session
8:30-8:40	Announcement / Housekeeping	
8:40-9:00	Capture fisheries studies in Kenya **Yoshiki Matsushita**	Fisheries and gear technology in Kenya and Tuna fishery
9:00-9:20	The tuna fisheries of mainland China ------ fisheries status, challenge and strategies **Liming Song**	
9:20-9:40	Prediction the shooting trajectory of tuna purse-seine for an unassociated fish school **Chun-Woo Lee**	
9:40-10:00	Hydrodynamic characteristics of tuna purse-seine netting panels with different knot types **Hao Tang**	
10:00-10:30	**COFFEE BREAK**	
10:30-10:50	**Discussion**	WGFTFB business
10:50-11:10	**Country report summary (Steve Eayrs)**	
11:10-11:30	**TOR a. Report/summary (Change)**	
11:30-11:50	**TOR b. Report/summary (Groundgear)**	
11:50-12:30	**TOR c. Report/summary (Energy)**	
12:30-13:40	**LUNCH BREAK**	
13:40 – 16:00	**ICES Issues, questions from other working groups**	
	Gear manual - (selectivity, how to measure and processing data)	
	Next meeting – Place and time	
	New TOR	
	Other business	
	Adjourn	

Annex 3: Recommendations

Recommendations	Addressed To
Organize a Workshop on Methods for Stakeholder Involvement in Gear Development (WKMSIGD)	SSGIEOM, ACOM, SCICOM

Annex 4: Workshop proposals and WGFTFB terms of reference

The **Workshop on Methods for Stakeholder Involvement in Gear Development (WKMSIGD)**, chaired by Jordan Feekings, Denmark, and Daniel Valentinsson, Sweden, will meet for 3 days (no date defined as yet) to:

a) Review current knowledge and experience in involving stakeholders in the development of fishing gears (ideally this should involve scientists, fishers and managers);

b) Propose future work looking at how to improve the methodologies current employed;

c) Develop standard procedures and methods for identifying optimal incentive structures, self-sampling methods, facilitating stakeholder involvement, and information transfer between initiatives;

d) Identify how these initiatives can facilitate the landing obligation and the proposal of the new technical measures;

Supporting Information

As described in the *Impact Assessment on a proposal for a regulation of the European Parliament and of the council on the conservation of fishery resources and the protection of marine ecosystems through technical measures (11.03.2016*), the current technical measures regime is no longer fit for achieving the sustainability objectives of the new common fisheries policy (CFP). Specifically, the current measures are:

- *based on negative, mostly coercive incentives in a top–down governance system creating mistrust among stakeholders as measures are seen as inequitable, leading to non-compliance;*
- *impossible to measure their impact on the achievement of the conservation objectives of the CFP;*
- *numerous and overly complex making compliance and control more difficult;*
- *controlling too many aspects of fishing operations undermining the sector's confidence in the measures;*
- *providing little incentive to fish selectively where there is no cost to discarding, or of catching vulnerable species or affecting adversely on the seabed; and*
- *suboptimal in respect of achieving broader environmental and ecological policy objectives*

The Impact assessment aimed to:

1. Optimize the contribution of technical measures to achieving the key objectives (to minimize/phase out discards) of the new CFP that came into force on 1 January 2014.
2. Create the flexibility required to adjust technical measures by facilitating regionalised approaches (consistent with the objectives in EU law).

Currently, there are several countries trialing initiatives which aim to have the fishing industry to develop the gears they perceive better suit their fisheries. The involvement of stakeholders in the development and testing of fishing gears can help to alleviate some of the mistrust and non-compliance currently observed, provide incentives to fish selectively, and help achieve the aims described in the Impact Assessment. The initiatives established are currently coordinated at a national level, where project structures, incentives, data collection methods etc. all differ from each other.

To be able to use such types of initiatives to help facilitate the landing obligation and the proposed reformed technical measures these initiatives should be coordinated at a regional level. This workshop aims to define how to obtain the most out of these initiatives.

Priority	Gear selectivity trials/improvements provide crucial information on the selectivity of fishing gears used in the fisheries and their descriptions in the technical regulations. Consequently, these activities are considered to have a high priority.
Scientific justification	TOR a) to d) The work currently being carried out by a number of member states on involving stakeholder in the development and testing of fishing gears is coordinated at a national level, where project structures, incentives, data collection methods etc. all differ from each other. To be able to use such types of projects to help facilitate the landing obligation and the proposed reformed technical measures these initiatives should be coordinated at a regional level.
Resource requirements	The national programs which provide the main input to this group are already underway, and resources are already committed. The additional resources required to undertake the workshop are meeting room facilities at ICES headquarters.
Participants	Members of WGFTFB (10-15 participants expected) and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	There are linkages to both SCICOM and ACOM.
Linkages to other committees or groups	There are links to WGFTFB.
Linkages to other organizations	The work of this group is of interest to all EU countries as it pertains to the landing obligation and how stakeholder driven gear development can facilitate a successful management framework.

Annex 5: Multiannual Term of Reference for ICES-FAO WGFTFB

The ICES-FAO **Working Group on Fishing Technology and Fish Behaviour** (WGFTFB), chaired by Haraldur A. Einarsson*, Iceland, and Petri Suuronen (FAO), will meet to work on the following Terms of References (ToRs) and produce deliverables as listed in the following table for the years 2017 through 2019. This multiyear ToRs will be updated annually. WGFTFB will report on the activities and findings by 25 June each year to SSGIEOM.

Year	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2017	4-7 April	Nelson, New Zealand	Interim report by 25 June to SSGIEOM	
Year 2018	4-8 June	Hirtshals, Denmark	Interim report by 13 July to SSGIEOM	
Year 2019	TBD	TBD	Interim report by 25 June to SSGIEOM	

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
A	Deliberate, discuss and synthesize recent research on topics related to: i) Designing, planning, and testing of fishing gears used in abundance estimation; ii) Selective fishing gears for the reduction of bycatch, discard and unaccounted mortality, especially as they relate to EU Landing Obligation; iii) Environmentally benign fishing gears and methods, iv) Improving fuel efficiency and reduction of emission from fisheries, and v) Summaries of research activities by nation	Through open sessions and focused, multiyear topic groups, the Working Group provides opportunities for collaboratively developing research proposals, producing reports and manuscripts, and creating technical manuals on current developments and innovations.	28,29, 30, 31primarily; others are possible (e.g. 11,12, 27)	3 Years	ICES report
B	Organize a FAO-hosted FAO-ICES mini-symposium with thematic issues. Symposium themes will be determined at Year 2, and included in the updated ToR.	Under mutual agreement between ICES and FAO, FAO develops and leads a mini-symposium of relevant topics, while also continuing ICES commitments.	29, 30	Year 3	FAO report, ICES report

C	Deliberate, discuss and synthesize recent research on topics of mutual interest between WGFTFB and WGFAST	Every three years, WGFAST and WGFTFB meet for one day to share information on topics of mutual interest (JFATB).	27, 30, 31	Year 1	JFATB report
D	Help organize an ICES-sponsored international fishing technology and fish behaviour symposium	The last similar symposium was ten years ago (2006).	28, 29, 30, 31	Fall 2020 (outside scope of this Multiannual ToR)	Symposium and special issue in ICES JMS
E	Support survey working group with gear expertise support upon request	SSGIEOM has identified gear expertise gaps in survey working groups.	31	Year 1,2	Including possible survey trawl workshop

Summary of the Work Plan

Year 1	Produce the annual report; hold joint session with WGFAST; connect to survey WGs
Year 2	Produce annual report; Continue development of relationships with survey WGs
Year 3	Produce the annual report; organize FAO-ICES mini-symposium

Supporting information

Priority	The activities of WGFTFB will provide ICES with knowledge and expertise on issues related to the ecosystem effects of fisheries, especially the evaluation and reduction of the impact of fishing on marine resources and ecosystems and the sustainable use of living marine resources and other topics related to the performance of commercial fishing gears and survey gears.
Resource requirements	The research programmes that provide the main input to this working group already exist, and resources are already committed by individual institutions. The additional resource required to undertake activities in the framework of this group is negligible. However, each institution is encouraged to support participation of experts from their institution.
Participants	The group is normally attended by about 40–50 regular members and chair-invited members. Participation is about 70 - 90 in the year when FAO-ICES mini-symposium is held.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	Linkages to advisory groups via reports on changes to fleets and fleet effort.
Linkages to other committees or groups	There is a very close working relationship with other groups of SSGIEOM, e.g. WGFAST, and the survey groups.
Linkages to other organizations	The WG is jointly sponsored with the FAO.